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ESTIMATED PUBLIC BENEFITS
OF IMPLEMENTING
THE PROPOSED REVISIONS
TO REGULATION 308

VOLUME 111 - APPENDICES D TO I

JULY 1990



Ontario

Environment
Environnement

Jim Bradley, Minister/ministre

ESTIMATED PUBLIC BENEFITS OF IMPLEMENTING
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VOLUME III - APPENDICES D TO I

Report Prepared by:
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In association with:
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and
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Ontario Ministry of the Environment

JULY 1990



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APPENDIX D

Emissions Data

APPENDIX D

CONTAMINANT EMISSIONS DATA SUPPLIED BY SENES CONSULTANTS

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)					
			Existing	A	B	C	D	E
OPEN PIT MINING								
0611	Gold Mines	PM	4,418.0	2,945.3	2,945.3	3,576.5	2,945.3	4,418.0
0617	Iron Ore	PM	2,857.4	1,978.2	1,978.2	2,307.9	1,978.2	2,857.4
TOTAL OPEN PIT MINING			7,275.4	4,923.5	4,923.5	5,884.4	4,923.5	7,275.4
FOOD INDUSTRIES								
1011	Meat & Meat Products							
	Slaughter Houses							
	Rendering	Odour Units	1E+10	9E+06	5E+06	1E+10	9E+06	1E+10
	Processing	(per plant)						
		PM	5.3	0.4	0.4	1.1	0.4	0.4
		VOC	6.3	0.7	0.7	2.1	0.7	0.7
1012	Poultry							
	Slaughter Houses							
	Rendering	Odour Units	2E+09	9E+06	5E+06	2E+09	9E+06	2E+09
	Processing	(per plant)						
		PM	1.2	0.1	0.1	0.2	0.1	0.1
		VOC	1.4	0.2	0.2	0.5	0.2	0.2
1021	Fish Plants							
		PM	0.1	0.0	0.0	0.0	0.0	0.0
		VOC	0.1	0.0	0.0	0.0	0.0	0.0

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)					
			Existing	A	B	C	D	E
1049	Other Dairy Whey Drying	PM	19.4	0.1	0.1	0.1	0.1	0.1
TOTAL FOOD INDUSTRIES		PM	26.0	0.5	0.5	1.4	0.5	0.5
		VOC	7.8	0.9	0.9	2.6	0.9	0.9
PULP & PAPER AND ALLIED PRODUCTS								
2711	Kraft Pulp Mills Recovery Boiler	PM	5,097.0	236.6	236.6	510.9	236.6	236.6
		SO2	3,226.5	1,608.5	1,608.5	3,226.5	1,608.5	3,226.5
		NOx	747.0	747.0	747.0	747.0	747.0	747.0
		CO	1,088.0	1,088.0	1,088.0	1,088.0	1,088.0	1,088.0
	Lime Kiln	PM	1,538.0	577.2	577.2	766.4	577.2	577.2
		SO2	85.2	85.2	85.2	85.2	85.2	85.2
		NOx	590.0	236.6	236.6	590.0	236.6	590.0
		CO	3,638.0	3,638.0	3,638.0	3,638.0	3,638.0	3,638.0
	Smelt Dissolving	PM	171.0	85.2	85.2	85.2	85.2	85.2
		SO2	27.0	27.0	27.0	27.0	27.0	27.0
	Steam Boilers	PM	87.0	28.4	28.4	28.4	28.4	28.4
		SO2	6,391.0	473.1	473.1	6,391.0	473.1	6,391.0
		NOx	1,532.0	378.5	378.5	1,532.0	378.5	1,532.0
		CO	1,648.0	1,648.0	1,648.0	1,648.0	1,648.0	1,648.0

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)					
			Existing	A	B	C	D	E
2712	Bleach Plant	Cl2	567.0	567.0	283.9	567.0	567.0	567.0
		ClO2	189.0	189.0	94.6	189.0	189.0	189.0
	Total 2711 Kraft Pulp Mills	PM	6893.0	927.3	927.3	1390.9	927.3	927.3
		SO2	9729.7	2193.8	2193.8	9729.7	2193.8	9,729.7
		NOx	2869.0	1362.0	1362.0	2869.0	1362.0	2,869.0
		CO	6374.0	6374.0	6374.0	6374.0	6374.0	6,374.0
		Cl2	567.0	567.0	283.9	567.0	567.0	567.0
		ClO2	189.0	189.0	94.6	189.0	189.0	189.0
	Newsprint Mills with kraft pulping	PM	3,377.0	55.4	55.4	343.2	55.4	55.4
		SO2	2,434.0	1,217.7	1,217.7	2,434.0	1,217.7	2,434.0
		NOx	496.0	496.0	496.0	496.0	496.0	496.0
		CO	692.0	692.0	692.0	692.0	692.0	692.0
Lime Kiln	PM	1,014.0	99.6	99.6	509.2	99.6	99.6	
	SO2	103.0	55.4	55.4	55.4	55.4	103.0	
	NOx	392.0	392.0	392.0	392.0	392.0	392.0	
	CO	2,280.0	2,280.0	2,280.0	2,280.0	2,280.0	2,280.0	
Smelt Dissolving	PM	112.0	55.4	55.4	55.4	55.4	55.4	
	SO2	34.0	33.2	33.2	33.2	33.2	34.0	

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)					
			Existing	A	B	C	D	E
2712	Steam Boilers	PM	102.0	33.2	33.2	33.2	33.2	33.2
		SO2	1,594.0	553.5	553.5	1,594.0	553.5	1,594.0
		NOx	1,223.0	442.8	442.8	1,223.0	442.8	1,223.0
		CO	1,734.0	1,734.0	1,734.0	1,734.0	1,734.0	1,734.0
	Bleach Plant	Cl2	164.0	164.0	77.5	164.0	164.0	164.0
		ClO2	221.0	221.0	110.7	221.0	221.0	221.0
	Newsprint Mills with sulphite pulping	SO2	230.0	138.0	46.0	230.0	138.0	230.0
		SO2	92.0	46.0	46.0	92.0	46.0	92.0
		PM	216.0	13.8	13.8	13.8	13.8	13.8
		NOx	216.0	184.0	184.0	216.0	184.0	216.0
		CO	562.0	562.0	562.0	562.0	562.0	562.0
		SO2	330.0	230.0	230.0	322.0	230.0	230.0
2712	Newsprint Mills with groundwood pulping	PM	682.0	13.5	13.5	13.5	13.5	13.5
		SO2	2,231.0	225.0	225.0	2,231.0	225.0	2,231.0
		NOx	355.0	180.0	180.0	355.0	180.0	355.0
		CO	1,378.0	1,378.0	1,378.0	1,378.0	1,378.0	1,378.0

SIC
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PLANT TYPE

CONTAMINANT
(See glossary
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the table.)

EMISSIONS BY SCENARIO (tonnes/year)

2712	Newsprint Mills		Existing	A	B	C	D	E
	Steam Boilers	PM	1,120.0	35.9	35.9	35.9	35.9	35.9
		SO2	5,660.0	597.5	597.5	5,660.0	597.5	5,660.0
		NOx	1,120.0	478.0	478.0	1,120.0	478.0	1,120.0
		CO	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0
Total 2712	Newsprint Mills	PM	6623.0	306.7	306.7	1,004.1	306.7	306.7
		SO2	12,708.0	3096.3	3004.3	12651.6	3096.3	12,608.0
		NOx	3802.0	2172.8	2172.8	3802.0	2172.8	3,802.0
		CO	8296.0	8296.0	8296.0	8296.0	8296.0	8,296.0
		Cl2	164.0	164.0	77.5	164.0	164.0	164.0
		ClO2	221.0	221.0	110.7	221.0	221.0	221.0
2713	Paperboard Mills with kraft pulping							
	Recovery Boiler	PM	3,704.0	1,854.0	1,854.0	1,854.0	1,854.0	1,854.0
		SO2	1,234.0	616.9	616.9	1,234.0	616.9	1,234.0
		NOx	469.0	469.0	469.0	469.0	469.0	469.0
		CO	740.0	740.0	740.0	740.0	740.0	740.0
	Lime Kiln	PM	1,110.0	109.8	109.8	555.6	109.8	109.8
		SO2	37.0	37.0	37.0	37.0	37.0	37.0
		NOx	370.0	370.0	370.0	370.0	370.0	370.0
		CO	2,470.0	2,470.0	2,470.0	2,470.0	2,470.0	2,470.0

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
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		Existing	A	B	C	D	E
2713	Smelt Dissolving	PM	62.0	32.3	32.3	32.3	32.3
		SO ₂	12.0	12.0	12.0	12.0	12.0
	Steam Boilers	PM	304.0	9.7	9.7	9.7	9.7
		SO ₂	91.0	91.0	91.0	91.0	91.0
		NO _x	252.0	129.2	252.0	129.2	252.0
		CO	493.0	493.0	493.0	493.0	493.0
	Bleach Plant	Cl ₂	81.0	42.0	81.0	81.0	81.0
		ClO ₂	2.0	2.0	2.0	2.0	2.0
	Paperboard Mills with semi-chem pulping	PM	48.0	1.5	1.5	1.5	1.5
		SO ₂	14.0	14.0	14.0	14.0	14.0
2713	Steam Boilers	NO _x	44.0	20.4	44.0	20.4	44.0
		CO	11.0	11.0	11.0	11.0	11.0
	Paperboard Mills	PM	340.0	22.5	22.5	22.5	22.5
		SO ₂	10.0	10.0	10.0	10.0	10.0
		NO _x	107.0	107.0	107.0	107.0	107.0
		CO	30.0	30.0	30.0	30.0	30.0

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CONTAMINANT
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EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
Total 2713 Paperboard Mills							
	PM	5568.0	2029.9	2029.9	2475.6	2029.9	2029.9
	SO ₂	1398.0	780.9	780.9	1398.0	780.9	1398.0
	NO _x	1242.0	1095.6	1095.6	1242.0	1095.6	1,242.0
	CO	3744.0	3744.0	3744.0	3744.0	3744.0	3,744.0
	Cl ₂	81.0	81.0	42.0	81.0	81.0	81.0
	ClO ₂	2.0	2.0	2.0	2.0	2.0	2.0
2811	Business Forms	6,330.0	63.3	63.3	6,330.0	63.3	6,330.0
2819	Other Commercial Print	3,646.0	364.6	36.5	3,645.8	364.6	3,646.0
2821	Platemaking	490.0	57.6	14.6	68.8	57.6	490.0
2841	Magazines & Newspapers	38,701.0	737.2	73.7	9,337.4	737.2	38,701.0
2849	Other Printing						
	Wallpaper						
	Other	0.2	0.2	0.2	0.2	0.2	0.2
	VOC	3,095.0	154.8	31.0	3,095.0	154.8	3,095.0
Total 2849 Other Printing	VOC	3,095.2	155.0	31.16	3,095.2	155.0	3,095.2

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			Existing	A	B	C	D	E
TOTAL PULP & PAPER AND ALLIED PRODUCTS								
		PM	19,084.0	3,263.9	3,263.9	4,870.6	3,263.9	3,263.9
		SO2	23,835.7	6,071.0	5,979.0	23,779.3	6,071.0	23,735.7
		NOx	7,913.0	4,630.4	4,630.4	7,913.0	4,630.4	7,913.0
		CO	18,414.0	18,414.0	18,414.0	18,414.0	18,414.0	18,414.0
		Cl2	812.0	812.0	403.3	812.0	812.0	812.0
		ClO2	412.0	412.0	207.3	412.0	412.0	412.0
		VOC	52,262.2	1,377.7	219.3	22,477.1	1,377.7	52,262.2
IRON AND STEEL INDUSTRIES								
2911	Ferro-Alloys	PM	18.9	0.3	0.3	0.3	0.3	0.3
		VOC	4.1	1.6	1.6	1.6	1.6	1.6
2912	Steel Foundries	PM	8,823.3	4,170.0	4,170.0	6,759.2	4,170.0	4,170.0
2919	Other Primary Steel							
	Electric Arc Boilers	PM	306.5	140.4	140.4	280.8	140.4	140.4
		PM	253.7	63.4	63.4	190.3	63.4	63.4
TOTAL IRON AND STEEL INDUSTRIES		PM	9,402.4	4,374.1	4,374.1	7,230.6	4,374.1	4,374.1
		VOC	4.1	1.6	1.6	1.6	1.6	1.6

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EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
FOUNDRIES							
2941	Iron Foundries	PM	11,406.1	1,267.3	1,267.3	2,534.7	1,267.3
2971	Copper/Brass Works	PM	305.8	54.9	54.9	109.8	54.9
2999	Rolled Casting						
	Copper	PM	92.0	13.5	13.5	24.4	13.5
	Aluminum	PM	186.0	2.5	2.5	55.8	2.5
		VOC	2.5	2.5	2.5	2.5	2.5
	Total 2999 Rolled Casting	PM	278.0	16.0	16.0	80.2	16.0
		VOC	2.5	2.5	2.5	2.48	2.5
	TOTAL FOUNDRIES	PM	11,989.9	1,338.2	1,338.2	2,724.6	1,338.2
		VOC	2.5	2.5	2.5	2.5	2.5

NON-FERROUS SMELTERS & REFINERIES

2959	Primary Smelters						
	Arsenic	132.9	8.9	8.9	14.8	8.9	8.9
	Copper	708.9	47.3	47.3	96.0	47.3	47.3
	Iron	1,897.7	127.0	127.0	251.1	127.0	127.0
	Lead	214.1	14.0	14.0	29.5	14.0	14.0
	Nickel	494.7	34.7	34.7	66.5	34.7	34.7
	PM	15,432.3	1,026.4	1,026.4	2,060.1	1,026.4	1,026.4
	Zinc	29.5	2.2	2.2	7.4	2.2	2.2

EMISSIONS BY SCENARIO (tonnes/year)

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			Existing	A	B	C	D	E
2959	Lead Smelters	PM	60.0	60.0	60.0	60.0	60.0	60.0
		Lead	5.5	5.5	5.5	5.5	5.5	5.5
TOTAL NON-FERROUS SMELTERS AND REFINERIES								
		Arsenic	132.9	8.9	8.9	14.8	8.9	8.9
		Copper	708.9	47.3	47.3	96.0	47.3	47.3
		Iron	1,897.7	127.0	127.0	251.1	127.0	127.0
		Lead	219.6	19.5	19.5	35.0	19.5	19.5
		Nickel	494.7	34.7	34.7	66.5	34.7	34.7
		PM	15,492.3	1,086.4	1,086.4	2,120.1	1,086.4	1,086.4
		Zinc	29.5	2.2	2.2	7.4	2.2	2.2

AUTOMOTIVE INDUSTRY

3231	Automotive & Parts Mfg	VOC	25,730.2	12,540.8	11,675.9	17,946.3	12,540.8	25,730.2				
3254	Steering/Suspension	PM	41.3	41.3	4.1	41.3	41.3	41.3	41.3	41.3	41.3	41.3
3255	Brake Lining and Aluminum Wheels	Asbestos	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		PM	0.3	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1
		Talc	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
3259	Batteries	Lead	51.1	2.6	2.6	5.2	2.6	2.6	2.6	2.6	2.6	2.6

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
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PLANT TYPE

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CODE

		Existing	A	B	C	D	E
TOTAL AUTOMOTIVE INDUSTRY		25,730.2	12,540.8	11,675.9	17,946.3	12,540.8	25,730.2
VOC		51.1	2.6	2.6	5.2	2.6	2.6
Lead		0.1	0.1	0.0	0.1	0.1	0.1
Asbestos		19.0	19.0	19.0	19.0	19.0	19.0
Talc		41.6	41.3	4.2	41.6	41.3	41.3
PM							

INORGANIC CHEMICAL MANUFACTURING INDUSTRIES

3511 Domestic Clay Products
Manufacturing

Raw Materials	PM	270.0	15.9	15.9	135.4	15.9	15.9
Tunnel Kiln (gas)	PM	111.5	63.7	63.7	111.5	63.7	63.7
(no control)	VOC	700.9	350.5	350.5	350.5	350.5	350.5
	NOx	111.5	111.5	63.7	111.5	111.5	111.5
	F	637.2	14.3	14.3	159.3	14.3	14.3
Gas-fired Dryer	PM	10.0	9.6	9.6	9.6	9.6	9.6
	SO2	876.0	446.0	446.0	446.0	446.0	446.0
Total 3511 Domestic Clay Products	PM	391.5	89.2	89.2	256.4	89.2	89.2
	NOx	111.5	111.5	63.7	111.5	111.5	111.5
	F	637.2	14.3	14.3	159.3	14.3	14.3
	SO2	876.0	446.0	446.0	446.0	446.04	446.0

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)							
			Existing	A	B	C	D	E		
3512	Imported Clay Products									
	Ceramics	PM (bag)	58.0	11.6	11.6	57.9	11.6	11.6		
		PM (WWS)	1,887.0	377.4	377.4	1,886.9	377.4	377.4		
	Total 3512 Imported Clay Products	PM	1,945.0	389.0	389.0	1,944.8	389.0	1,945.0		
3521	Cement Industry									
		Wet Kiln	PM	513.0	173.3	173.3	346.5	173.3	173.3	
			SO2	9,324.0	4,725.0	4,725.0	4,725.0	4,725.0	4,725.0	
			NOX	10,206.0	10,206.0	10,206.0	10,206.0	10,206.0	10,206.0	
		Dry Kiln	PM	907.0	307.1	307.1	614.3	307.1	307.1	
			SO2	13,860.0	7,087.5	7,087.5	7,087.5	7,087.5	7,087.5	
			NOX	15,309.0	15,309.0	15,309.0	15,309.0	15,309.0	15,309.0	
		Clinker Cool (ff)	PM	2,438.0	122.9	122.9	122.9	122.9	122.9	
			PM	1,625.0	81.9	81.9	81.9	81.9	81.9	
			PM	354.0	181.1	181.1	181.1	181.1	181.1	
		Raw Feed Mill	PM	512.0	259.9	259.9	259.9	259.9	259.9	
			PM	284.0	141.8	141.8	141.8	141.8	141.8	
		Total 3521 Cement Industry		PM	6,633.0	1,267.9	1,267.9	1,748.3	1,267.9	1,267.9
				SO2	23,184.0	11,812.5	11,812.5	11,812.5	11,812.5	11,812.5
NOX	25,515.0			25,515.0	25,515.0	25,515.0	25,515.0	25,515.0		

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
3571	Abrasives						
	Aluminum Oxide	541.0	138.6	138.6	138.6	138.6	138.6
	Silicon Carbide	376.0	96.3	96.3	96.3	96.3	96.3
		3,667.0	185.7	185.7	366.7	185.7	185.7
Total 3571	Abrasives						
		917.0	234.9	234.9	234.9	234.9	234.9
		3,667.0	185.7	185.7	366.7	185.7	185.7
3581	Lime						
	Lime Kiln	1,660.0	829.9	829.9	1,659.7	829.9	829.9
	Product Hydration	154.0	92.6	92.6	154.0	92.6	92.6
	Crushing & Grinding	1,500.0	21.6	21.6	450.4	21.6	21.6
	Stockpiles	10.5	5.2	5.2	5.2	5.2	5.2
	Storage	9.5	4.9	4.9	4.9	4.9	4.9
Total 3581	Lime	3,334.0	954.2	954.2	2,274.3	954.2	954.2

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

		Existing	A	B	C	D	E
3711	General Inorganic Chemicals						
	Ammonia Products						
	PM	684.0	33.5	33.5	68.0	33.5	33.5
	SO2	845.0	27.9	27.9	51.2	27.9	27.9
	NOX	136.0	48.4	48.4	82.0	48.4	48.4
	F	3.4	0.0	0.0	3.0	0.0	0.0
	HC	1,221.0	12.1	12.1	122.0	12.1	12.1
	NH3	272.0	27.0	27.0	54.0	27.0	27.0
	PM	87.2	0.6	0.6	4.3	0.6	0.6
	HC	4.7	4.7	4.7	4.7	4.7	4.7
	Ammonium Phosphate						
	PM	1,565.0	156.5	156.5	469.5	156.5	156.5
Urea & Carbon	PM	236.0	22.4	22.4	89.4	22.4	22.4
	SO2						
	NOX	111.0	55.5	55.5	88.8	55.5	55.5
	HC	1,453.0	14.5	14.5	145.3	14.5	14.5
	NH3	0.0	0.0	0.0	0.0	0.0	0.0
Phosphoric Acid	PM	145.0	14.5	14.5	145.0	14.5	14.5
	F	3.3	0.3	0.3	3.3	0.3	0.3
	HC	38.0	3.8	3.8	38.0	3.8	3.8
Carbon Pellets	PM	844.0	84.5	84.5	84.5	84.5	84.5
	VOC	4,846.0	49.1	49.1	4,846.0	49.1	49.1
Nitric Acid	PM	136.0	135.7	135.7	135.7	135.7	135.7
	NOX	1,781.0	622.5	622.5	1,066.9	622.5	622.5
	HC	7.4	0.7	0.7	7.4	0.7	0.7

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)					
			Existing	A	B	C	D	E
Total 3711	Ammonium Nitrate (99.5%)	PM	751.0	79.0	79.0	750.6	79.0	79.0
		HC	113.0	26.3	26.3	113.0	26.3	26.3
		NH3	2,412.0	237.0	237.0	2,409.8	237.0	237.0
		Nitric Acid	328.0	39.5	39.5	328.0	39.5	39.5
		PM	712.0	76.0	76.0	709.1	76.0	76.0
		HC	266.0	25.3	25.3	265.9	25.3	25.3
	Ammonium Nitrate (63%)	NH3	2,450.0	240.6	240.6	2,443.8	240.6	240.6
		Nitric Acid	350.0	38.0	38.0	350.0	38.0	38.0
		PM	85.0	1.4	1.4	1.7	1.4	1.4
	Ammonium Phosphate	HC	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
		NH3	38.3	38.3	38.3	38.3	38.3	38.3
		F	22.2	0.6	0.6	2.8	0.6	0.6
3721	General Inorganic Chemicals	PM	5,009.2	581.7	581.7	2,368.4	581.7	581.7
		SO2	1,081.0	50.3	50.3	140.7	50.3	50.3
		NOx	2,028.0	726.5	726.5	1,237.7	726.5	726.5
		F	28.9	0.9	0.9	9.1	0.9	0.9
		HC	4,603.1	1,587.6	1,587.6	2,196.3	1,587.6	1,587.6
		NH3	5,172.3	542.9	542.9	4,945.9	542.9	542.9
		Nitric Acid	678.0	77.5	77.5	678.0	77.5	77.5
		VOC	4846.0	49.1	49.1	4846.0	49.1	49.1
		PM	1.6	0.1	0.1	0.7	0.1	0.1
		Chemical Fertilizer						

SIC
CODE

PLANT TYPE

CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

TOTAL INORGANIC CHEMICAL MANUFACTURING INDUSTRIES							
Existing	A	B	C	D	E		
	PM	18,231.3	3,517.0	3,517.0	8,827.9	3,517.0	5,073.0
	SO2	28,808.0	12,494.5	12,494.5	12,765.9	12,494.5	12,494.5
	NOx	27,654.5	26,353.0	26,305.2	26,864.2	26,353.0	26,353.0
	F	666.1	15.2	15.2	168.4	15.2	15.2
	HC	4,603.1	1,587.6	1,587.6	2,196.3	1,587.6	1,587.6
	NH3	5,172.3	542.9	542.9	4,945.9	542.9	542.9
	VOC	4,846.0	49.1	49.1	4,846.0	49.1	49.1
	Nitric Acid	678.0	77.5	77.5	678.0	77.5	77.5

PETROLEUM REFINERIES

3611 Refineries

Process Combustion

Oil

Oil

SO₂SO₂NO_x

PM

VOC

SO₂NO_x

PM

SO₂SO₂

Cracker

Sulphur Plant

Flares, Vents

12,550.7	6,641.0	3,218.1	12,433.7	6,641.0	12,550.7
14,774.1	7,694.3	3,218.1	14,774.1	7,694.3	14,774.1
6,436.3	3,861.8	2,925.6	3,861.8	3,861.8	6,436.3
2,852.4	351.1	351.1	710.9	351.1	351.1
93.6	29.3	29.3	46.8	29.3	93.6
8,571.9	4,095.8	4,095.8	8,191.6	4,095.8	8,571.9
1,424.8	942.0	731.4	942.0	942.0	1,424.8
1,755.3	731.4	731.4	731.4	731.4	731.4
5,500.1	2,750.0	2,047.9	5,500.1	2,750.0	5,500.1
1,387.0	1,387.0	1,387.0	1,387.0	1,387.0	1,387.0

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	Existing				
			A	B	C	D	E
	Tanks Storage Pumps, Compressor	VOC	1,928.0	1,462.8	1,928.0	1,462.8	1,928.0
		VOC	672.9	526.6	526.6	526.6	672.9
TOTAL PETROLEUM REFINERIES			42,783.8	22,568.1	42,286.5	22,568.1	42,783.9
		SO2	7,861.1	4,803.8	3,657.0	4,803.8	7,861.0
		NOX	4,607.7	1,082.5	1,442.3	1,082.5	1,082.5
		PM	2,694.5	2,018.6	1,784.6	2,018.6	2,694.5
		VOC					
ASPHALT PAVING INDUSTRY							
3699	Asphalt Paving Plants	PM	720.0	720.0	720.0	720.0	720.0
	Permanent	PM	369.0	123.0	246.0	123.0	369.0
	Portable						
TOTAL ASPHALT PAVING INDUSTRY			1,089.0	843.0	966.0	843.0	1,089.0
ORGANIC CHEMICAL PRODUCTS INDUSTRY							
3712	Industrial Organic Chemicals	PM	145.0	14.6	145.0	14.6	14.6
		NOx	4,607.8	1,082.5	1,442.3	1,082.5	1,082.5
		VOC	326.0	32.7	326.0	32.7	32.7
	P/C						

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

Existing	A	B	C	D	E
Vinyl Chloride	1,442.0	148.3	1,441.4	148.3	148.3
	3,684.0	3,681.8	1,614.4	3,681.8	3,684.0
	700.0	70.0	700.0	70.0	70.0
	679.2	68.5	679.2	68.5	68.5
	158.0	155.7	28.7	155.7	158.0
P.E.P.X.T.	7,072.0	1,432.5	1,432.5	1,432.5	1,432.5
	34.0	0.0	0.2	0.0	0.0
	14.0	2.8	13.8	2.8	2.8
Benzene	12.0	0.0	0.1	0.0	0.0
	1,053.0	10.6	53.0	10.6	10.6
Styrene	2.0	0.0	0.1	0.0	0.0
	26.0	0.3	26.0	0.3	0.3
S.A.B.	2,314.2	231.4	2,266.0	231.4	231.4
	8,449.8	4,920.0	2,725.5	4,920.0	4,924.5
	9,191.0	1,548.8	1,548.8	2,551.3	1,548.8
Total 3712 Industrial Organic Chemicals	1,307.5	0.1	0.1	0.1	0.1
3731 Plastics & Resins					
3751 Paint & Varnish Paint	24.1	0.0	0.1	0.0	0.0
	1,104.0	1.2	1.2	5.6	1.2
	2,265.0	2.4	2.4	11.5	2.4
Varnish Paint					

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

		Existing	A	B	C	D	E
Total 3751 Paint & Varnish							
	PM	24.1	0.0	0.0	0.1	0.0	0.0
	VOC	3369.0	3.6	3.6	17.1	3.6	3.6
3791 Printing Ink							
	Solvent	34.4	1.3	1.3	1.9	1.3	1.3
	Pigment	0.2	0.0	0.0	0.1	0.0	0.0
3792 Adhesives							
	VOC	0.4	0.0	0.0	0.0	0.0	0.4
3799 Other Chemicals							
	Metallic	52.4	5.4	5.4	35.0	5.4	5.4
	Plasticizer &	190.0	182.7	121.3	182.7	182.7	190.0
	Solvent Reclamation	9,700.0	498.3	498.3	996.7	498.3	498.3
	Pigment Paint	4,012.0	659.4	659.4	1,310.9	659.4	659.4
Total 3799 Other Chemicals							
	PM	4,012.0	659.4	659.4	1,310.9	659.4	659.4
	Nox	190.0	182.7	121.3	182.7	182.7	190.0
	VOC	9,700.0	498.3	498.3	996.7	498.3	498.3
	Pb	52.4	5.4	5.4	35.0	5.4	5.4
TOTAL ORGANIC CHEMICAL PRODUCTS INDUSTRIES							
	PM	6,350.3	890.9	890.9	3,577.2	890.9	890.9
	Nox	8,639.8	5,102.7	2,846.8	5,462.6	5,102.7	5,114.5
	VOC	22,294.8	2,052.1	2,052.1	3,567.0	2,052.1	2,052.5
	Styrene	1,307.5	0.1	0.1	0.1	0.1	0.1
	Lead	52.4	5.4	5.4	35.0	5.4	5.4

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE	CONTAMINANT (see glossary at the end of the table.)	Existing	A	B	C	D	E
POWER GENERATION								
4911	Electric Power Industries							
	Lakeview	PM	5,130.4	1,971.6	996.4	5,130.4	1,971.6	5,130.4
	Lambton	PM	6,247.1	1,664.7	841.3	6,247.1	1,664.7	6,247.1
	Nanticoke	PM	7,575.6	3,292.2	1,663.8	7,575.6	3,292.2	7,575.6
	Thunder Bay	PM	500.4	370.8	187.2	500.4	370.8	500.4
	Atikokan	PM	300.0	194.0	98.0	300.0	194.0	300.0
	Lennox	PM	443.9	443.9	443.9	443.9	443.9	443.9
TOTAL POWER GENERATION			20,197.4	7,937.2	4,230.6	20,197.4	7,937.2	20,197.4

WASTE DISPOSAL INDUSTRIES

4999	Transfer Station	Odour Units	50.0	0.0	0.0	4.5	0.0	0.0
Municipal Landfill								
	1 CH4		3,298.0	67.3	67.3	101.0	67.3	67.3
	ROG		34.0	0.3	0.3	1.5	0.3	0.3
	2 CH4		1,843.0	37.6	37.6	56.4	37.6	37.6
	ROG		19.0	0.2	0.2	0.8	0.2	0.2
	3 CH4		58.0	1.2	1.2	1.8	1.2	1.2
	ROG		0.9	0.3	0.3	0.9	0.3	0.3

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(See glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

	Existing	A					B					C					D					E				
S-S Incinerator	PM	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9	240.9			
	SO2	307.0	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4	90.4				
	NOx	188.0	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4	105.4				
	HCl	571.0	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5				
	Pb	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4				
	Hg	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
	Cd	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5				
	Cr	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6				
	PCDD	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012				
	PCDF	0.00230	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023				
	PCB	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
	MC Incinerator	PM	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7	357.7			
SO2		32.0	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6				
NOx		102.0	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7				
HCl		42.6	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0				
Pb		0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01				
Hg		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01				
Cd		1.10	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22				
Cr		0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01				
PCDD		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
PCDF		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
PCB		0.30	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.1				

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(see glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

Existing

A

B

C

D

E

4999
Sewage Sludge
Incinerators

MH Incinerator

PM

SO₂NO_x

HC

HCl

Pb

29.3

35.2

176.0

58.5

11.7

0.02

29.3

35.2

176.0

58.5

11.7

0.02

29.3

35.2

176.0

58.5

11.7

0.02

29.3

35.2

176.0

58.5

11.7

0.02

FB Incinerator

PM

SO₂NO_x

HC

HCl

Pb

106.7

28.4

152.4

58.6

17.6

0.10

29.3

28.4

152.4

58.6

11.7

0.02

29.3

28.4

152.4

58.6

11.7

0.02

29.3

28.4

152.4

58.6

11.7

0.02

4999
Private Waste DisposalCommercial and
Industrial Incinerators

PM

SO₂NO_x

CO

HC

Pb

Hg

4.9

40.6

73.0

178.5

24.3

0.040

4.9

40.6

73.0

178.5

24.3

4.9

40.6

73.0

178.5

24.3

0.040

4.9

40.6

73.0

178.5

24.3

0.040

EMISSIONS BY SCENARIO (tonnes/year)

CONTAMINANT
(see glossary
at the end of
the table.)

PLANT TYPE

SIC
CODE

4999	Institutional Waste Disposal	Existing	Emissions (kg/day)					
			A	B	C	D	E	
TOTAL WASTE DISPOSAL INDUSTRIES	Hospitals							
	PM	108.3	0.5	0.5	1.0	0.5	0.5	
	Organic Acids	71.3	0.4	0.4	0.7	0.4	0.4	
	Nox	58.0	0.3	0.3	0.6	0.3	0.3	
	Aldehydes	46.6	0.2	0.2	0.5	0.2	0.2	
	PM	971.0	657.7	657.7	658.2	657.7	657.7	
	SO2	466.7	220.1	220.1	226.5	220.1	220.1	
	Nox	1,325.8	536.8	536.8	780.2	536.8	536.8	
	HCl	648.8	161.0	161.0	186.5	161.0	161.0	
	Pb	3.5	2.5	2.5	2.5	2.5	2.5	
	Hg	0.4	0.4	0.4	0.4	0.4	0.4	
	Cd	2.6	1.7	1.7	2.6	1.7	1.7	
	Cr	0.7	0.6	0.6	0.7	0.6	0.6	
	PCDD	0.0012	0.0012	0.0012	0.0012	0.0012	0.0	
PCDF	0.002	0.002	0.002	0.002	0.002	0.0		
PCB	0.5	0.2	0.2	0.5	0.2	0.2		
CH4	5,199.0	106.1	106.1	159.2	106.1	106.1		
ROG	53.9	0.8	0.8	3.2	0.8	0.8		
Organic Acids	71.3	0.4	0.4	0.7	0.4	0.4		
Aldehydes	46.6	0.2	0.2	0.5	0.2	0.2		
CO	178.5	178.5	178.5	178.5	178.5	178.5		
HC	141.6	141.6	141.6	141.6	141.6	141.6		

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	Existing	A	B	C	D	E
DRY CLEANERS								
9721	Dry Cleaning Solvent Reclamation Closed System	Perchloroethylene	50.0	0.0	0.0	0.0	0.0	0.0
TOTAL DRY CLEANERS			50.0	0.0	0.0	0.0	0.0	0.0

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RESTAURANTS

9211	Restaurants	Odour Units (per restaurant)	6E+09	6E+06	6E+06	6E+09	6E+06	6E+09
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GLOSSARY

As	=	Arsenic	Hg	=	Mercury
Cd	=	Cadmium	NH ₃	=	Ammonia
CH ₄	=	Methane	Ni	=	Nickel
Cl	=	Chlorine	NO _x	=	Nitrogen Oxides
ClO ₂	=	Chlorine Dioxide	Pb	=	Lead
CO	=	Carbon Monoxide	PCB	=	Polychlorinated Biphenols
Cr	=	Chromium	PCDD	=	Polychlorinated Dibenzo Dioxins
Cu	=	Copper	PCDF	=	Mixture of Chlorinated Dibenzo Dioxins and Chlorinated Dibenzo Furans
F	=	Fluorides	PM	=	Particulate Matter
Fe	=	Iron	ROG	=	Reactive Organic Gases
HC	=	Hydrocarbons	SO ₂	=	Sulphur Dioxide
HCl	=	Hydrogen Chloride	VOC	=	Volatile Organic Compounds

APPENDIX E

Speciation Profiles

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E.1 THE REQUIREMENT

The emissions data supplied by Senes Consultants Ltd. (see Appendix D) include two broad categories of contaminants, namely particulate matter (PM) and volatile organic compounds (VOC's). These broad categories include dozens (PM) or hundreds (VOC) of different chemicals.

Reduced emissions of particulate matter, regardless of the composition, can yield health (respiratory problems, eye irritations etc.) and other (soiling, visibility reduction) benefits. But most health and environmental benefits derived from reduced emissions of PM's and VOC's result from lower concentrations of specific chemicals. Thus, the composition of the VOC and PM emissions must be determined so that the changes in emissions of specific chemicals can be examined. This was one of the major challenges of the project.

E.2 APPROACH

Not surprisingly, the composition of the VOC's (PM's) emitted varies with the specific industrial process. The emissions from a coal-fired boiler, a gas-fired boiler and an oil-fired boiler are different. To determine the composition of VOC (PM) emissions, it is necessary to begin with the processes used in each economic sector.

E.2.1 Speciation

The only source of detailed data on the composition of VOC's and PM's is of the United States Environmental Protection Agency's (EPA), National Emissions Data System (NEDS).

As in Canada, U.S. industries are classified by Standard Industrial Classification (SIC) codes. Unfortunately, U.S. SIC codes differ from Canadian SIC codes.

In the NEDS database each U.S. SIC is divided into processes which are regarded as sources of emissions and are assigned a unique Source Classification Code (SCC). To use the SCC information on PM and VOC composition we needed to:

- . select the SCC's that correspond to each of the Canadian industries or industry segments covered by this study;
- . ensure that the SCC's selected correspond to the processes and emissions estimated by Senes; and
- . aggregate the SCC profiles of PM's and VOC's into profiles corresponding to the Canadian SIC codes covered by this study.

These steps are described below.

E.3 IDENTIFICATION OF SCC'S

The first task is to identify the unique Source Classification Codes (SCC's) needed for our analysis. The Canadian SIC codes for the industries or industry segments covered by the study are known. Statistics Canada provides a conversion table that relates each Canadian SIC code to the corresponding U.S. SIC codes. We used this conversion table to identify the relevant U.S. SIC codes. The number of U.S. SIC codes identified was approximately 50 per cent larger than the corresponding number of Canadian SIC codes.

We then obtained from the National Emissions Data System (NEDS) data for the SCC's corresponding to the identified U.S. SIC codes. We received data on approximately 15,000 SCC's.

E.4 SCC DATA

The data obtained for each SCC included:

- . the U.S. SIC code that uses the process;
- . the type of process;
- . a description of the process including notes such as the fuel used;
- . the corresponding speciation profile number which identifies the specific chemicals that comprise the VOC (PM) emissions for that process; and
- . the total VOC (PM) emissions from the given process by all plants in the United States in 1985.

In theory each SCC has a unique chemical breakdown for its VOC emissions and its PM emissions. In practice, generalized profiles are common to many SCC's. For example, the composition of the VOC and PM emissions from oil-fired boilers might be similar for many industries (SIC's) that use such boilers.

It is also important to understand that the SCC's corresponding to a given SIC code do not represent a single set of processes found in all plants in that industry. Sticking with the boiler example, a given SIC code may have SCC's that correspond to oil-fired, coal-fired, and gas-fired boilers. A given plant might use only a single fuel for its boiler, so only one of the SCC's would be relevant for its emissions.

E.5 ELIMINATION OF MINOR SCC'S

As mentioned above, a large number (more than 15,000) processes (SCC's) are sources of emissions in the industrial sectors we considered. We had to find some way of cutting down this number to make the calibration of SCC's with the industry sectors covered by the study and the emissions data provided by Senes a manageable task.

We used the following procedure. We eliminated all SCC's whose contribution to total PM or total VOC emissions in the (U.S.) SIC in question was less than 5 percent.¹ In most cases, we were left with a small group of SCC's which contributed 75 percent or more of total PM or VOC emissions of U.S. firms in that industry.

In a few instances we were left with less than 75 percent of total PM or VOC emissions using the "less than 5 percent" rule. In those cases we conducted an ordered search for "minor" SCC's and put them back in the SCC grouping for the American SIC in question. We kept adding "minor" SCC's until we had 75 percent of total PM and total VOC emissions accounted for. Our ordered search involved looking for the most important SCC's of less than 5 percent, i.e., 4-5 percent, the 3-4 percent, etc.

The process of eliminating minor SCC's reduced the number from over 15,000 to less than 1,000.

¹ Only if the SCC contributed less than 5 percent of both total VOC and PM emissions was it excluded. If the SCC contributed 5.1 percent of total VOC emissions and 1.0 percent of total PM emissions it was retained.

E.6 ELIMINATION OF SUB-SECTORS NOT COVERED BY THIS STUDY

The American SIC codes include sub-sectors that are not found in Ontario or were excluded from this study. For example, the American SIC code for fish processing includes canneries which are not found in Ontario. Hence, the canneries sub-sector and related SCC's were excluded. Similarly, only the coating operations of the automotive and automotive parts industries are addressed in this study. Hence, SCC's relating to other processes in the automotive and automotive parts industries were eliminated.

Few problems were encountered in matching the sector and sub-sector definitions to those within the scope of this study. Matching the process definitions, with the exception of boilers, also did not create any problems. Where questions arose we contacted Senes Consultants to ensure that the sub-sector and/or process coverage in terms of SCC's matched emission sources they identified in Ontario.

E.7 BOILERS

Boilers are an integral part of many industrial processes. They are also used to provide space heating for larger buildings. It is not surprising then to find that a number of the SCC's related to boilers. However, Senes advised us that boilers are not important sources of emissions in many of the sectors studied and hence boiler emissions were not included in their estimated emissions for these sectors.

Boilers therefore presented three problems for the analysis:

- . Whether, for a particular economic sector, the boiler aspect should be included or not.
- . Whether boilers used for space heat should be considered.
- . If it was decided to include boiler emissions in a particular sector, how the speciation of VOC and PM emissions obtained from the U.S. should be adjusted to account for the greater use of natural gas and oil in Ontario relative to the United States.

Our approach to these problems is described below. The approach is apparently simplistic, but we considered it better to be consistent in a project with uncertainty, in any case, so prevalent.

E.7.1 Boiler Inclusion in the Analysis

The EPA NEDS database may indicate that boilers are sources of VOC's and PM's in a particular U.S. industrial sector. Regardless of that information, we followed the advice of the consultants who provided the emissions data (Senes) as to whether boilers had in fact been included in their calculations. If boiler emissions were included in the emissions estimates, EPA boiler speciations were used for PM's and VOC's emitted by the sector in question. If boiler emissions were not included in the emissions estimates, the SCC's relating to boilers were dropped.

Eliminating the emissions from boilers had the effect of reducing the percentage of total VOC or PM emissions covered by the selected SCC's below 75 percent of total VOC and PM emissions by that industry in most cases.

E.7.2 Boiler Use for Space Heat

Emissions from boilers used for space heating were excluded in all cases, except to the extent that the boiler would be included as part of the general boiler use in the sector.

E.7.3 Boiler Fuel Conversion, Sectors

We judged it necessary to make boiler fuel conversions in three sectors: electric power generation, pulp and paper, and petroleum refineries.

Ontario Hydro information for the six power generation plants examined in this study indicates that only three fuels are used: lignite coal, bituminous coal, and heavy fuel oil. The EPA data also indicated boilers fueled by wood bark waste, distillate oil and natural gas. We treated these fuels as heavy fuel oil and adjusted emissions as described below.

In the pulp and paper sector, we assumed that wood bark waste, natural gas, and heavy fuel oil are used in Ontario. Where EPA identified the use of coal, we treated these emissions as if they came from heavy fuel oil. For petroleum refineries, we assumed natural gas and heavy fuel oil are used to fuel boilers. Where EPA referred to use of light oil, we converted this to heavy fuel oil.

E.7.4 Boiler Fuel Conversion, Procedure

Next we had to convert emissions from one fuel type to another. We used the following procedure.

Sentes provided us with information on VOC and PM emissions per tonne of steam for different fuels by boiler type (i.e., the many different kinds of boiler that are powered by one type of fuel).

VOC and PM emissions per tonne of steam do not vary greatly by boiler type. The emissions per tonne of steam depend much more on the fuel used than on the boiler design. We calculated typical VOC and PM emissions per tonne of steam by fuel type, regardless of the boiler type.

To convert the EPA data from one boiler fuel to another, we started from the premise that the steam required would not change. Then the quantity and composition of the VOC and PM emissions resulting from the generation of that steam were adjusted to reflect the different boiler fuel.

For example, assume the NEDS data for the pulp and paper industry indicated that particulate emissions from bituminous coal-fired boilers amounted to 500 tonnes per year. The steam generated was estimated at $(500 \times 1,000/5.35 =)$ 93,458 tonnes per year.² Assuming this same 93,458 tonnes of steam was generated by a heavy oil fired boiler, the PM emissions would be $(93,458 \times 0.075/1,000 =)$ 7 tonnes per year.³ The magnitude of this shift in PM emissions -- from 500 tonnes to 7 tonnes in the example -- indicates why we felt it important to adjust the mix of boiler fuels where possible.

The PM emissions estimated by converting from one boiler fuel to another (bituminous coal to heavy oil) were added to the emissions reported by the NEDS database for the substitute fuel (heavy oil). The SCC profile for boilers using that fuel was assumed to apply to the revised total emissions.

² 500 tonnes of PM x 1,000 kg/tonne divided by PM emissions of 5.35 kg per tonne of steam.

³ 93,458 tonnes of steam x 0.075 kg of PM emissions per tonne of steam/1,000 kg per tonne = 7 tonnes of PM emissions.

These calculations eliminate some SCC profiles -- those for the boiler fuels that have been converted -- from the set of profiles for the industry and assign higher total PM and VOC emissions to other SCC profiles -- those for the substitute fuels -- for that industry. The total emissions of PM and VOC by SCC obtained from the NEDS database, adjusted for the different mix of boiler fuels, are used as weights for the SCC profiles in the calculation of overall PM and VOC emissions profiles for the industry.

This process may appear unsatisfactory. However, the reader should remember that the objective of the speciation process is to define the characteristic proportions of contaminants in the emissions from a particular economic sector. Thus, apparent errors resulting from our adjustments may alter the composition of the VOC or PM emissions speciations somewhat, but will not affect the total amount of such emissions. The amounts are those estimated by Senes.

E.8 CALCULATION OF SPECIATIONS

Having identified the SCC's that account for the bulk of the VOC and PM emissions in the sectors and sub-sectors of interest for this study and having adjusted the process fuels where appropriate, it remained to calculate a VOC and PM speciation for each industry. That was done as follows.

All of the selected SCC's corresponding to a given Canadian SIC were identified. The composition of each of these SCC's was determined from the NEDS database. This lists every chemical that is found in the VOC (PM) emissions by that SCC together with the percent weight of that chemical of total VOC (PM) emitted by that process (SCC) by U.S. plants in 1985. Next, weighted

averages of the same contaminant from different SCC's were combined. This total was used to determine each contaminant's percentage share of the total VOC (PM) emissions for a specific Canadian SIC.

In a few instances, the emissions data provided by Senes Consultants (Appendix D) identifies separately chemicals that are constituents of the PM or VOC emissions. We checked with them to determine whether those chemicals were emitted separately, in addition to the emissions that of that chemical as part of the PM or VOC emissions. Where the emissions were said to be part of the PM or VOC emissions, the quantities of that chemical estimated by the speciation of the PM or VOC emissions were subsequently replaced by Senes' estimate of emissions for the contaminant. This uses the more relevant information generated by Senes, and eliminates double counting of emissions of those contaminants.

E.9 RESULTS

The PM and VOC speciations for the Canadian SIC codes used in this analysis are shown below.

The profiles break down the PM and VOC emissions into their constituent chemicals. Some of those constituent chemicals are Regulation 308 Contaminants. Others are not on the list of 96 chemicals we were asked to consider. Each profile shows the percentage contribution of each Regulation 308 Contaminant and a balance percentage of "other" chemicals making up the profile.

This "other" category typically accounts for most -- usually over 60 percent -- of the PM or VOC emissions in a sector. The relatively large size of this "other" category raised the concern

that potentially harmful contaminants were being overlooked. To allay this concern we provided a list of all VOC and PM chemicals on the NEDS database to the Ministry of the Environment for review. The Ministry was satisfied that the list of contaminants originally specified identified the chemicals of concern. This review led to the addition of three chemicals to the list of contaminants.

Thus, the "other" category can be considered to consist of relatively harmless chemicals. The steps taken to reduce the more hazardous chemicals in the VOC or PM emission streams will have the effect of lowering emissions of these more benign constituents as well at no additional cost. Because of the relatively benign nature of these "other" chemicals no benefits are deemed to be derived from their curtailment.

OPEN PIT MINING

SIC 0611 Gold Mines

PM Contaminant Per Cent

SILICA	31.42
OTHER	68.58
Subtotal	100.00

SIC 0617 Iron Ore Mines

PM Contaminant Per Cent

ARSENIC	2.64
CADMIUM	0.75
CHROMIUM	0.23
FLUORIDE	0.52
MERCURY	0.01
MANGANESE	0.68
NICKEL	0.14
LEAD	4.93
SELENIUM	0.05
SILICA	4.54
TIN	0.20
OTHER	85.30
Subtotal	99.99

FOOD INDUSTRIES

SIC 1011 Meat and Meat Products

PM Contaminant	Per Cent
SILICA	15.00
OTHER	85.00
Subtotal	100.00

VOC Contaminant	Per Cent
BENZENE	0.11
ETHYLBENZENE	0.01
ETHYLENE	0.63
FORMALDEHYDE	0.81
TOLUENE	0.04
OTHER	98.40
Subtotal	100.00

SIC 1012 Poultry Products

PM Contaminant	Per Cent
SILICA	15.00
OTHER	85.00
Subtotal	100.00

VOC Contaminant	Per Cent
OTHER	100.00
Subtotal	100.00

SIC 1021 Fish Products

PM Contaminant Per Cent

SILICA	15.00
OTHER	85.00
Subtotal	100.00

SIC 1049 Other Dairy Products (Whey Drying)

PM Contaminant Per Cent

ARSENIC	0.23
CADMIUM	0.07
CHROMIUM	0.03
FLUORIDE	0.05
MERCURY	0.01
MANGANESE	0.07
NICKEL	0.03
LEAD	0.68
SELENIUM	0.01
SILICA	13.76
TIN	0.03
OTHER	85.04
Subtotal	100.01

VOC Contaminant

Per Cent

OTHER	100.00
Subtotal	100.00

PULP AND PAPER AND ALLIED PRODUCTS

SIC 2711 Pulp Industry

PM Contaminant Per Cent

ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.03
FLUORIDE	1.19
MERCURY	0.08
MANGANESE	0.15
NICKEL	0.03
LEAD	0.01
SELENIUM	0.02
SILICA	0.55
TIN	0.02
OTHER	97.90
Subtotal	100.00

VOC Contaminant

Per Cent

BENZENE	7.62
ETHYLBENZENE	0.48
ETHYLENE	6.67
FORMALDEHYDE	9.48
TOLUENE	1.00
OTHER	74.74
Subtotal	99.99

SIC 2712 Newsprint Industry

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.02
FLUORIDE	0.85
MERCURY	0.05
MANGANESE	0.12
NICKEL	0.43
LEAD	0.02
SELENIUM	0.01
SILICA	2.03
TIN	0.02
OTHER	96.43
Subtotal	100.00

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.02
1,3-BUTADIENE	0.06
ACRYLONITRILE	0.05
BENZENE	9.46
BUTYL ACRYLATE	0.03
BUTYL CELLOSOLVE	0.02
CARBON TETRACHLORIDE	0.04
CELLOSOLVE	0.02
CELLOSOLVE ACETATE	0.02
CHLOROFORM	0.03
EPICHLOROHYDRIN	0.02
ETHYLBENZENE	0.73
ETHYLENE	7.48
ETHYLENE DIBROMIDE	0.02
ETHYLENE DICHLORIDE	0.09
ETHYLENE OXIDE	0.02
FORMALDEHYDE	4.55
METHYL ETHYL KETONE	0.11
METHYL ISOBUTYL KETONE	0.04
NAPHTHALENE	0.03
PERCHLOROETHYLENE	0.04
PHENOL	0.55
PROPIONALDEHYDE	0.02
PROPIONIC ACID	0.02
PROPYLENE OXIDE	0.03
STYRENE	0.17
TOLUENE	2.16
TOLUENE DIISOCYANATE	0.04
TRICHLOROETHYLENE	0.02
VINYL CHLORIDE	0.06
OTHER	74.06
Subtotal	100.01

SIC 2713 Paperboard Industry

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.01
FLUORIDE	1.18
MERCURY	0.08
MANGANESE	0.17
NICKEL	0.50
LEAD	0.02
SILICA	2.06
TIN	0.02
OTHER	95.92
Subtotal	99.98

VOC Contaminant	Per Cent
BENZENE	11.08
ETHYL BENZENE	0.43
ETHYLENE	9.75
FORMALDEHYDE	6.69
TOLUENE	0.76
OTHER	71.27
Subtotal	99.98

SIC 2811 Business Forms Printing

VOC Contaminant	Per Cent
METHYL ETHYL KETONE	54.27
METHYL ISOBUTYL KETONE	14.78
TOLUENE	6.48
OTHER	24.47
Subtotal	100.00

SIC 2819 Other Commercial Printing

PM Contaminant	Per Cent
ARSENIC	1.04
CADMIUM	0.34
CHROMIUM	0.12
FLUORIDE	0.22
MERCURY	0.05
MANGANESE	0.32
NICKEL	0.12
LEAD	3.10
SELENIUM	0.03
SILICA	8.36
TIN	0.15
OTHER	86.17
Subtotal	100.02

VOC Contaminant	Per Cent
BENZENE	0.04
BUTYL CELLOSOLVE	0.11
CELLOSOLVE	0.01
ETHYL BENZENE	3.77
ETHYLENE	0.12
ETHYLENE DIBROMIDE	0.07
FORMALDEHYDE	1.22
METHYL ETHYL KETONE	5.51
METHYL ISOBUTYL KETONE	2.71
TOLUENE	3.73
OTHER	82.67
Subtotal	99.96

SIC 2821 Plate Making, Typesetting and Bindery

PM Contaminant	Per Cent
CADMIUM	0.01
FLUORIDE	0.36
MANGANESE	0.04
NICKEL	0.01
LEAD	0.01
SILICA	0.21
TIN	0.01
OTHER	99.35
Subtotal	100.00

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.03
1,3-BUTADIENE	0.05
ACRYLONITRILE	0.04
BENZENE	0.20
BUTYL ACRYLATE	0.03
BUTYL CELLOSOLVE	6.06
CARBON TETRACHLORIDE	0.05
CELLOSOLVE	0.03
CELLOSOLVE ACETATE	0.03
CHLOROFORM	0.04
EPICHLOROHYDRIN	0.03
ETHYLBENZENE	0.55
ETHYLENE	0.20
ETHYLENE DI Bromide	0.03
ETHYLENE DICHLORIDE	0.04
ETHYLENE OXIDE	0.03
FORMALDEHYDE	0.11
METHYL ETHYL KETONE	0.59
METHYL ISOBUTYL KETONE	0.37
NAPHTHALENE	0.01
PERCHLOROETHYLENE	0.05
PHENOL	0.03
PROPIONALDEHYDE	0.03
PROPIONIC ACID	0.03
PROPYLENE OXIDE	0.04
STYRENE	0.08
TOLUENE	35.36
TOLUENE DIISOCYANATE	0.05
TRICHLOROETHYLENE	0.03
VINYL CHLORIDE	0.03
OTHER	55.77
Subtotal	100.02

SIC 2841 Newspaper, Magazine and Periodical Publishing

VOC Contaminant	Per Cent
BUTYL CELLOSOLVE	0.43
ETHYLBENZENE	0.28
ETHYLENE	0.03
ETHYLENE DI Bromide	0.14
FORMALDEHYDE	0.36
METHYL ETHYL KETONE	12.16
METHYL ISOBUTYL KETONE	4.79
TOLUENE	6.50
OTHER	75.31
Subtotal	100.00

SIC 2849 Other Combined Publishing and
Printing Industries

VOC Contaminant	Per Cent
ETHYLBENZENE	6.00
OTHER	94.00
Subtotal	100.00

IRON AND STEEL INDUSTRIES

SIC 2911 Ferro-Alloys

PM Contaminant	Per Cent
ARSENIC	0.21
CADMIUM	0.20
CHROMIUM	1.38
MANGANESE	0.29
NICKEL	0.10
LEAD	3.56
SELENIUM	0.02
SILICA	6.61
TIN	0.01
OTHER	87.61
Subtotal	99.99

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.04
1,3-BUTADIENE	0.38
ACRYLONITRILE	0.05
BENZENE	9.28
BUTYL ACRYLATE	0.04
BUTYL CELLOSOLVE	0.04
CARBON TETRACHLORIDE	0.06
CELLOSOLVE	0.03
CELLOSOLVE ACETATE	0.03
CHLOROFORM	0.05
EPICHLOROHYDRIN	0.04
ETHYLBENZENE	0.06
ETHYLENE	19.56
ETHYLENE DIBROMIDE	0.04
ETHYLENE DICHLORIDE	0.05
ETHYLENE OXIDE	0.04
FORMALDEHYDE	0.15
METHYL ETHYL KETONE	0.11
METHYL ISOBUTYL KETONE	0.05
NAPHTHALENE	0.02
PERCHLOROETHYLENE	0.07
PHENOL	0.04
PROPIONALDEHYDE	0.04
PROPIONIC ACID	0.04
PROPYLENE OXIDE	0.05
STYRENE	0.11
TOLUENE	0.64
TOLUENE DIISOCYANATE	0.06
TRICHLOROETHYLENE	0.04
VINYL CHLORIDE	0.04
OTHER	68.75
Subtotal	100.00

SIC 2912 Steel Foundries

PM Contaminant	Per Cent
ARSENIC	0.02
CADMIUM	0.03
CHROMIUM	1.36
MANGANESE	3.35
NICKEL	1.04
LEAD	0.50
SILICA	2.92
TIN	0.01
OTHER	90.75
Subtotal	99.98

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.43
1,3-BUTADIENE	0.67
ACRYLONITRILE	0.58
BENZENE	2.82
BUTYL ACRYLATE	0.43
BUTYL CELLOSOLVE	0.44
CARBON TETRACHLORIDE	0.65
CELLOSOLVE	0.36
CELLOSOLVE ACETATE	0.36
CHLOROFORM	0.51
EPICHLOROHYDRIN	0.42
ETHYLBENZENE	0.65
ETHYLENE	2.86
ETHYLENE DIISOCYANATE	0.42
ETHYLENE DICHLORIDE	0.58
ETHYLENE OXIDE	0.38
FORMALDEHYDE	1.55
METHYL ETHYL KETONE	1.22
METHYL ISOBUTYL KETONE	0.56
NAPHTHALENE	0.18
PERCHLOROETHYLENE	0.70
PHENOL	0.44
PROPIONALDEHYDE	0.42
PROPIONIC ACID	0.40
PROPYLENE OXIDE	0.50
STYRENE	1.20
TOLUENE	2.04
TOLUENE DIISOCYANATE	0.66
TRICHLOROBENZENES	0.01
TRICHLOROETHYLENE	0.43
VINYL CHLORIDE	0.42
OTHER	76.67
Subtotal	99.96

SIC 2919 Other Primary Steel Industries

PM Contaminant	Per Cent
ARSENIC	0.08
CADMIUM	0.09
CHROMIUM	0.76
FLUORIDE	0.07
MANGANESE	5.06
NICKEL	0.20
LEAD	1.63
SELENIUM	0.01
SILICA	0.85
OTHER	91.25
Subtotal	100.00

VOC Contaminant	Per Cent
1,3-BUTADIENE	0.18
ACRYLONITRILE	0.19
BENZENE	2.16
BUTYL ACRYLATE	0.04
BUTYL CELLOSOLVE	2.09
CARBON TETRACHLORIDE	0.06
CHLOROFORM	0.01
ETHYLBENZENE	0.30
ETHYLENE	1.76
ETHYLENE DICHLORIDE	0.50
ETHYLENE OXIDE	0.01
FORMALDEHYDE	0.54
METHYL ETHYL KETONE	2.56
METHYL ISOBUTYL KETONE	1.79
NAPHTHALENE	0.03
PHENOL	0.33
STYRENE	0.89
TOLUENE	20.36
TRICHLOROBENZENES	0.01
VINYL CHLORIDE	0.32
OTHER	65.88
Subtotal	100.01

FOUNDRIES

SIC 2941 Iron Foundries

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.08
MANGANESE	3.24
NICKEL	0.10
LEAD	0.38
SILICA	13.58
OTHER	82.59
Subtotal	99.99

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.05
1,3-BUTADIENE	0.08
ACRYLONITRILE	0.07
BENZENE	1.42
BUTYL ACRYLATE	0.05
BUTYL CELLOSOLVE	4.04
CARBON TETRACHLORIDE	0.08
CELLOSOLVE	0.04
CELLOSOLVE ACETATE	0.04
CHLOROFORM	0.06
EPICHLOROHYDRIN	0.05
ETHYLBENZENE	0.41
ETHYLENE	0.36
ETHYLENE DIBROMIDE	0.05
ETHYLENE DICHLORIDE	0.07
ETHYLENE OXIDE	0.05
FORMALDEHYDE	0.21
METHYL ETHYL KETONE	0.48
METHYL ISOBUTYL KETONE	0.29
NAPHTHALENE	0.02
PERCHLOROETHYLENE	0.09
PHENOL	3.13
PROPIONALDEHYDE	0.05
PROPIONIC ACID	0.05
PROPYLENE OXIDE	0.06
STYRENE	0.15
TOLUENE	23.97
TOLUENE DIISOCYANATE	0.08
TRICHLOROETHYLENE	0.05
VINYL CHLORIDE	0.05
OTHER	64.34
Subtotal	99.94

SIC 2971 Copper and Copper Alloy
Rolling, Casting and Extruding

PM Contaminant	Per Cent
ARSENIC	0.03
CADMIUM	0.01
CHROMIUM	0.02
MANGANESE	0.71
NICKEL	0.02
LEAD	0.37
SILICA	3.60
TIN	0.01
OTHER	95.25
Subtotal	100.02

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	6.93
BENZENE	0.31
BUTYL CELLOSOLVE	3.33
ETHYLBENZENE	0.28
METHYL ETHYL KETONE	0.62
METHYL ISOBUTYL KETONE	0.18
NAPHTHALENE	0.01
PERCHLOROETHYLENE	18.30
TOLUENE	22.03
TRICHLOROETHYLENE	6.55
OTHER	41.45
Subtotal	99.99

SIC 2999 Other Rolled, Cast and Extruded
Non-Ferrous Metal Products

PM Contaminant	Per Cent
ARSENIC	0.06
CADMIUM	0.05
CHROMIUM	1.85
MANGANESE	0.61
NICKEL	0.53
LEAD	0.95
SILICA	4.80
TIN	0.06
OTHER	91.08
Subtotal	99.99

VOC Contaminant	Per Cent
PERCHLOROETHYLENE	100.00
Subtotal	100.00

NON-FERROUS METAL SMELTING AND REFINING

SIC 2959 Other Primary Smelting and Refining of Non-Ferrous Metal

PM Contaminant Per Cent

ARSENIC	25.48
CADMIUM	1.46
CHROMIUM	0.22
FLUORIDE	1.47
MERCURY	0.04
MANGANESE	0.32
NICKEL	0.09
LEAD	12.25
SELENIUM	0.23
SILICA	2.25
TIN	0.32
OTHER	55.86
Subtotal	99.99

VOC Contaminant

Per Cent

BENZENE	4.01
ETHYLENE	0.01
FORMALDEHYDE	7.98
TOLUENE	2.00
OTHER	85.99
Subtotal	99.99

MOTOR VEHICLE INDUSTRIES

SIC 3231 Motor Vehicles and Motor Vehicle Parts and Accessories Surface Coating

PM Contaminant Per Cent

CADMIUM	0.05
CHROMIUM	0.05
NICKEL	0.05
OTHER	99.85
Subtotal	100.00

VOC Contaminant

Per Cent

BENZENE	1.04
ETHYLBENZENE	8.68
TOLUENE	20.12
OTHER	70.16
Subtotal	100.00

SIC 3254 Motor Vehicle Steering and
Suspension Parts

PM Contaminant Per Cent

OTHER	99.99
Subtotal	99.99

VOC Contaminant

Per Cent

1,1,1-TRICHLOROETHANE	1.89
1,3-BUTADIENE	0.96
ACRYLONITRILE	0.01
BENZENE	0.39
BUTYL CELLOSOLVE	0.76
ETHYLBENZENE	2.33
ETHYLENE	2.29
ETHYLENE DICHLORIDE	0.02
FORMALDEHYDE	0.44
METHYL ETHYL KETONE	0.17
METHYL ISOBUTYL KETONE	0.04
PERCHLOROETHYLENE	0.63
PHENOL	0.01
PROPIONALDEHYDE	0.01
STYRENE	0.04
TOLUENE	12.76
TRICHLOROETHYLENE	1.79
VINYL CHLORIDE	0.01
OTHER	75.45
Subtotal	100.00

INORGANIC CHEMICAL MANUFACTURING

SIC 3511 Domestic Clay Products

PM Contaminant Per Cent

ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.17
FLUORIDE	0.03
MANGANESE	0.07
NICKEL	0.06
LEAD	0.17
SELENIUM	0.06
SILICA	7.67
OTHER	91.76
Subtotal	100.01

VOC Contaminant

Per Cent

BENZENE	3.76
ETHYLBENZENE	3.29
ETHYLENE	0.08
FORMALDEHYDE	2.96
NAPHTHALENE	0.10
TOLUENE	5.59
OTHER	84.21
Subtotal	99.99

SIC 3512 Imported Clay Products

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.12
FLUORIDE	0.02
MANGANESE	0.04
NICKEL	0.04
LEAD	0.11
SELENIUM	0.04
SILICA	6.72
OTHER	92.90
Subtotal	100.01

VOC Contaminant	Per Cent
1,3-BUTADIENE	0.01
ACRYLONITRILE	0.01
BENZENE	0.09
BUTYL CELLOSOLVE	2.63
ETHYLBENZENE	0.81
ETHYLENE	0.08
ETHYLENE DIBROMIDE	0.09
ETHYLENE DICHLORIDE	0.02
FORMALDEHYDE	0.07
METHYL ETHYL KETONE	2.56
METHYL ISOBUTYL KETONE	1.62
PHENOL	0.01
STYRENE	0.04
TOLUENE	25.71
VINYL CHLORIDE	0.01
OTHER	66.22
Subtotal	99.98

SIC 3521 Hydraulic Cement

PM Contaminant	Per Cent
CADMIUM	0.01
CHROMIUM	0.22
FLUORIDE	0.12
MANGANESE	0.02
NICKEL	0.03
LEAD	0.83
SELENIUM	0.01
SILICA	5.48
OTHER	93.29
Subtotal	100.01

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.25
1,3-BUTADIENE	0.39
ACRYLONITRILE	0.34
BENZENE	2.60
BUTYL ACRYLATE	0.25
BUTYL CELLOSOLVE	0.26
CARBON TETRACHLORIDE	0.38
CELLOSOLVE	0.21
CELLOSOLVE ACETATE	0.21
CHLOROFORM	0.30
EPICHLOROHYDRIN	0.25
ETHYLBENZENE	0.56
ETHYLENE	2.15
ETHYLENE DI Bromide	0.25
ETHYLENE DICHLORIDE	0.34
ETHYLENE OXIDE	0.22
FORMALDEHYDE	4.95
METHYL ETHYL KETONE	0.72
METHYL ISOBUTYL KETONE	0.33
NAPHTHALENE	0.27
PERCHLOROETHYLENE	0.41
PHENOL	0.26
PROPIONALDEHYDE	0.25
PROPIONIC ACID	0.24
PROPYLENE OXIDE	0.29
STYRENE	0.71
TOLUENE	1.76
TOLUENE DIISOCYANATE	0.39
TRICHLOROBENZENES	0.01
TRICHLOROETHYLENE	0.25
VINYL CHLORIDE	0.25
OTHER	79.91
Subtotal	99.96

3571 Abrasives

PM Contaminant	Per Cent
ARSENIC	0.47
CADMIUM	0.15
CHROMIUM	0.05
FLUORIDE	0.10
MERCURY	0.02
MANGANESE	0.14
NICKEL	0.05
LEAD	1.40
SELENIUM	0.01
SILICA	3.47
TIN	0.06
OTHER	94.08
Subtotal	100.00

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.02
1,3-BUTADIENE	0.13
ACRYLONITRILE	0.13
BENZENE	1.26
BUTYL ACRYLATE	0.05
BUTYL CELLOSOLVE	0.02
CARBON TETRACHLORIDE	0.07
CELLOSOLVE	0.02
CELLOSOLVE ACETATE	0.02
CHLOROFORM	0.03
EPICHLOROHYDRIN	0.02
ETHYLBENZENE	0.84
ETHYLENE	1.09
ETHYLENE DIBROMIDE	0.74
ETHYLENE DICHLORIDE	0.30
ETHYLENE OXIDE	0.03
FORMALDEHYDE	0.37
METHYL ETHYL KETONE	3.47
METHYL ISOBUTYL KETONE	0.06
NAPHTHALENE	0.02
PERCHLOROETHYLENE	0.04
PHENOL	0.20
PROPIONALDEHYDE	0.02
PROPIONIC ACID	0.02
PROPYLENE OXIDE	0.03
STYRENE	0.54
TOLUENE	12.36
TOLUENE DIISOCYANATE	0.03
TRICHLOROBENZENES	0.01
TRICHLOROETHYLENE	0.02
VINYL CHLORIDE	0.19
OTHER	77.84
Subtotal	99.99

SIC 3581 Lime

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.17
FLUORIDE	0.03
MANGANESE	0.07
NICKEL	0.06
LEAD	0.17
SELENIUM	0.06
SILICA	7.67
OTHER	91.76
Subtotal	100.01

VOC Contaminant	Per Cent
BENZENE	1.38
ETHYLBENZENE	0.81
ETHYLENE	1.67
FORMALDEHYDE	15.19
TOLUENE	1.48
OTHER	79.46
Subtotal	99.99

SIC 3711 Industrial Inorganic Chemicals
(NEC)

PM Contaminant	Per Cent
CADMIUM	0.04
CHROMIUM	0.01
MANGANESE	0.03
NICKEL	0.04
LEAD	0.02
SELENIUM	0.01
SILICA	1.62
TIN	0.01
OTHER	98.23
Subtotal	100.01

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.54
1,3-BUTADIENE	0.56
ACRYLONITRILE	0.23
BENZENE	3.19
BUTYL ACRYLATE	0.06
BUTYL CELLOSOLVE	0.01
CARBON TETRACHLORIDE	0.08
CHLOROFORM	0.02
EPICHLOROHYDRIN	0.01
ETHYLBENZENE	0.72
ETHYLENE	4.21
ETHYLENE DI Bromide	0.01
ETHYLENE DICHLORIDE	2.10
ETHYLENE OXIDE	0.02
FORMALDEHYDE	0.11
METHYL ETHYL KETONE	0.49
METHYL ISOBUTYL KETONE	0.07
PERCHLOROETHYLENE	0.19
PHENOL	0.37
PROPIONALDEHYDE	0.01
PROPIONIC ACID	0.01
PROPYLENE OXIDE	0.01
STYRENE	5.74
TOLUENE	0.85
TOLUENE DIISOCYANATE	0.01
TRICHLOROETHYLENE	0.51
VINYL CHLORIDE	0.38
OTHER	79.52
Subtotal	100.03

SIC 3721 Chemical Fertilizer and
Fertilizer Materials

PM Contaminant	Per Cent
ARSENIC	0.05
CADMIUM	0.05
CHROMIUM	0.03
FLUORIDE	0.01
MANGANESE	0.09
NICKEL	0.04
LEAD	0.16
SELENIUM	0.03
SILICA	4.04
TIN	0.02
OTHER	95.46
Subtotal	99.98

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.01
1,3-BUTADIENE	0.02
ACRYLONITRILE	36.80
BENZENE	2.73
BUTYL ACRYLATE	0.07
BUTYL CELLOSOLVE	0.01
CARBON TETRACHLORIDE	0.10
CELLOSOLVE	0.01
CELLOSOLVE ACETATE	0.01
CHLOROFORM	0.03
EPICHLOROHYDRIN	0.01
ETHYLBENZENE	0.19
ETHYLENE	2.31
ETHYLENE DIISOCYANATE	0.01
ETHYLENE DICHLORIDE	0.69
ETHYLENE OXIDE	0.03
FORMALDEHYDE	0.78
METHYL ETHYL KETONE	0.55
METHYL ISOBUTYL KETONE	0.08
NAPHTHALENE	0.01
PERCHLOROETHYLENE	0.02
PHENOL	0.45
PROPIONALDEHYDE	0.01
PROPIONIC ACID	0.01
PROPYLENE OXIDE	0.02
STYRENE	25.44
TOLUENE	0.73
TOLUENE DIISOCYANATE	0.02
TRICHLOROETHYLENE	0.01
VINYL CHLORIDE	0.44
XYLENE BASE ACIDS	0.01
OTHER	28.35
Subtotal	99.96

PETROLEUM REFINERIES

SIC 3611 Petroleum Refineries

PM Contaminant Per Cent

ARSENIC	0.01
CHROMIUM	0.14
FLUORIDE	0.02
MANGANESE	0.03
NICKEL	1.51
LEAD	0.07
SELENIUM	0.13
SILICA	8.57
OTHER	89.51
Subtotal	99.99

VOC Contaminant

Per Cent

BENZENE	2.60
ETHYLBENZENE	0.36
ETHYLENE	0.01
FORMALDEHYDE	6.69
NAPHTHALENE	0.07
STYRENE	0.01
TOLUENE	1.75
OTHER	88.51
Subtotal	100.00

ASPHALT PAVING INDUSTRY

SIC 3699 Asphalt Paving Industry

PM Contaminant Per Cent

ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.15
FLUORIDE	0.02
MANGANESE	0.07
NICKEL	0.05
LEAD	0.15
SELENIUM	0.06
SILICA	6.73
OTHER	92.75
Subtotal	100.00

VOC Contaminant

Per Cent

1,3-BUTADIENE	0.01
ACRYLONITRILE	0.01
BENZENE	2.95
CARBON TETRACHLORIDE	0.01
CHLOROFORM	0.01
ETHYLBENZENE	1.25
ETHYLENE	0.03
ETHYLENE DICHLORIDE	0.01
FORMALDEHYDE	5.53
METHYL ETHYL KETONE	0.01
METHYL ISOBUTYL KETONE	0.01
NAPHTHALENE	1.02
PERCHLOROETHYLENE	0.01
PROPYLENE OXIDE	0.01
STYRENE	0.01
TOLUENE	4.28
TOLUENE DIISOCYANATE	0.01
OTHER	84.81
Subtotal	99.98

ORGANIC CHEMICAL PRODUCTS

SIC 3712 Industrial Organic Chemicals
(NEC)

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.04
CHROMIUM	0.02
MERCURY	0.16
MANGANESE	0.09
NICKEL	0.06
LEAD	0.27
SELENIUM	0.02
SILICA	4.45
TIN	0.05
OTHER	94.84
Subtotal	100.01

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.01
1,3-BUTADIENE	2.08
ACRYLONITRILE	4.11
BENZENE	4.32
BUTYL ACRYLATE	0.08
BUTYL CELLOSOLVE	0.01
CARBON TETRACHLORIDE	0.12
CHLOROFORM	0.02
EPICHLOROHYDRIN	0.01
ETHYLBENZENE	0.50
ETHYLENE	16.89
ETHYLENE DIBROMIDE	0.01
ETHYLENE DICHLORIDE	2.36
ETHYLENE OXIDE	0.03
FORMALDEHYDE	0.05
METHYL ETHYL KETONE	2.72
METHYL ISOBUTYL KETONE	0.09
PERCHLOROETHYLENE	0.01
PHENOL	0.87
PROPIONALDEHYDE	0.01
PROPIONIC ACID	0.01
PROPYLENE OXIDE	0.02
STYRENE	5.50
TOLUENE	0.80
TOLUENE DIISOCYANATE	0.01
TRICHLOROETHYLENE	0.01
VINYL CHLORIDE	3.16
XYLENE BASE ACIDS	0.01
OTHER	56.17
Subtotal	100.00

SIC 3731 Plastics and Synthetics Resins

PM Contaminant	Per Cent
CADMIUM	0.04
CHROMIUM	0.02
MANGANESE	0.12
NICKEL	0.03
LEAD	0.01
SELENIUM	0.02
SILICA	5.95
TIN	0.03
OTHER	93.80
Subtotal	100.02

VOC Contaminant	Per Cent
BENZENE	0.70
FORMALDEHYDE	1.41
TOLUENE	0.35
OTHER	97.55
Subtotal	100.01

SIC 3751 Paint and Varnish

PM Contaminant	Per Cent
CADMIUM	0.03
CHROMIUM	0.02
MANGANESE	0.12
NICKEL	0.02
LEAD	0.01
SELENIUM	0.01
SILICA	5.93
TIN	0.03
OTHER	93.81
Subtotal	99.98

VOC Contaminant	Per Cent
1,3-BUTADIENE	10.45
BENZENE	0.01
ETHYLENE	0.01
FORMALDEHYDE	0.01
METHYL ETHYL KETONE	7.61
PHENOL	5.36
STYRENE	6.97
TOLUENE	31.70
OTHER	37.84
Subtotal	99.96

SIC 3791 Printing Ink

PM Contaminant	Per Cent
CADMIUM	0.04
CHROMIUM	0.02
MANGANESE	0.12
NICKEL	0.03
LEAD	0.01
SELENIUM	0.02
SILICA	5.95
TIN	0.03
OTHER	93.80
Subtotal	100.02

VOC Contaminant	Per Cent
ETHYLBENZENE	3.00
METHYL ETHYL KETONE	5.00
OTHER	92.00
Subtotal	100.00

SIC 3792 Adhesives

PM Contaminant	Per Cent
CADMIUM	0.05
CHROMIUM	0.04
MANGANESE	0.04
NICKEL	0.04
SELENIUM	0.01
SILICA	1.98
TIN	0.01
OTHER	97.84
Subtotal	100.01

VOC Contaminant	Per Cent
1,3-BUTADIENE	0.07
ACRYLONITRILE	0.07
BENZENE	0.82
BUTYL ACRYLATE	0.02
BUTYL CELLOSOLVE	0.09
CARBON TETRACHLORIDE	0.02
CELLOSOLVE	0.57
CELLOSOLVE ACETATE	0.57
ETHYLBENZENE	0.12
ETHYLENE	0.69
ETHYLENE DIBROMIDE	0.01
ETHYLENE DICHLORIDE	0.19
ETHYLENE OXIDE	0.57
FORMALDEHYDE	0.21
METHYL ETHYL KETONE	1.08
METHYL ISOBUTYL KETONE	0.15
NAPHTHALENE	0.01
PHENOL	9.03
STYRENE	0.35
TOLUENE	1.32
VINYL CHLORIDE	0.12
OTHER	83.89
Subtotal	99.97

SIC 3799 Other Chemical Products (NEC)

PM Contaminant	Per Cent
CADMIUM	0.03
CHROMIUM	0.05
MANGANESE	0.05
NICKEL	0.07
LEAD	0.01
SELENIUM	0.05
SILICA	3.05
TIN	0.01
OTHER	96.70
Subtotal	100.02

VOC Contaminant	Per Cent
ACRYLONITRILE	0.11
BENZENE	0.74
BUTYL ACRYLATE	0.01
CARBON TETRACHLORIDE	0.02
ETHYLBENZENE	0.04
ETHYLENE	0.91
ETHYLENE DICHLORIDE	0.17
ETHYLENE OXIDE	0.08
FORMALDEHYDE	0.03
METHYL ETHYL KETONE	0.13
METHYL ISOBUTYL KETONE	0.02
PHENOL	10.44
PROPYLENE OXIDE	0.02
STYRENE	0.32
TOLUENE	0.19
VINYL CHLORIDE	0.12
XYLENE BASE ACIDS	0.02
OTHER	86.62
Subtotal	99.99

ELECTRIC POWER SYSTEMS

SIC 4911 Electric Power Systems - Coal
and Heavy Oil Fired Generating Stations

PM Contaminant	Per Cent
ARSENIC	0.05
CHROMIUM	0.06
MERCURY	0.01
MANGANESE	0.04
NICKEL	0.25
LEAD	0.17
SELENIUM	0.02
SILICA	20.06
TIN	0.01
OTHER	79.32
Subtotal	99.99

VOC Contaminant	Per Cent
1,3-BUTADIENE	0.28
BENZENE	0.37
ETHYLBENZENE	5.88
ETHYLENE	1.87
FORMALDEHYDE	14.19
PROPIONALDEHYDE	0.01
TOLUENE	2.96
OTHER	74.39
Subtotal	99.95

WASTE DISPOSAL INDUSTRIES

SIC 4999 Hospital Incinerators

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.06
CHROMIUM	0.02
MERCURY	2.67
MANGANESE	0.04
NICKEL	0.01
LEAD	4.12
TIN	0.44
OTHER	92.64
Subtotal	100.01

SIC 4999 Municipal and Commercial
Incinerators

PM Contaminant Per Cent

ARSENIC	0.02
CADMIUM	0.09
CHROMIUM	0.03
FLUORIDE	0.02
MERCURY	3.99
MANGANESE	0.07
NICKEL	0.01
LEAD	6.15
SILICA	0.05
TIN	0.66
OTHER	88.93
Subtotal	100.02

VOC Contaminant

Per Cent

BENZENE	7.28
ETHYLENE	9.27
OTHER	83.43
Subtotal	99.98

SIC 4999 Sewage Sludge Incinerators

PM Contaminant Per Cent

CADMIUM	0.83
CHROMIUM	0.58
MANGANESE	0.21
LEAD	2.94
SELENIUM	0.15
SILICA	4.77
TIN	1.39
OTHER	89.13
Subtotal	100.00

VOC Contaminant

Per Cent

BENZENE	7.70
ETHYLENE	8.70
OTHER	83.60
Subtotal	100.00

DRY CLEANING ESTABLISHMENTS

SIC 9721 Dry Cleaners

PM Contaminant Per Cent

ARSENIC	1.18
CADMIUM	0.38
CHROMIUM	0.13
FLUORIDE	0.24
MERCURY	0.05
MANGANESE	0.34
NICKEL	0.13
LEAD	3.50
SELENIUM	0.03
SILICA	8.67
TIN	0.16
OTHER	85.19
Subtotal	100.00

VOC Contaminant

Per Cent

BENZENE	0.03
ETHYLBENZENE	0.16
FORMALDEHYDE	0.07
NAPHTHALENE	0.16
PERCHLOROETHYLENE	13.23
PHENOL	4.93
TOLUENE	0.25
OTHER	81.20
Subtotal	100.03

APPENDIX F

Dispersion Modelling

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F.1 INTRODUCTION

This appendix describes the dispersion modelling work performed to estimate grids for annual average concentration of air emissions in various parts of Ontario.

F.1.1 Organization of the Work

The principal steps in the work are:

- . selection of a model;
- . selection of locations for which the model is run;
- . compilation of required meteorological data for each location;
- . specification of source characteristics; and
- . quality assurance checks of the model results.

The approach taken to each of these steps is outlined in the following sections.

F.1.2 Acknowledgement

We are grateful for the valuable assistance provided by the Air and Meteorology Section of the Ontario Ministry of the Environment in the use of their proposed dispersion models and advice in development of input parameters. In particular we would like thank Drs. P.K. Misra, R.N. Bloxam, H. Sahota, and L. Bradizza.

We also appreciate the assistance of staff of the Canadian Climate Centre, Atmospheric Environment Service, Environment Canada and U.S. National Climatic Data Centre.

F.2 SELECTION OF A DISPERSION MODEL

F.2.1 Proposed Dispersion Model

Our original proposal described a regulatory dispersion model presently in use in the Province of Alberta. This model was a variant of the existing Ontario regulatory model (a Pasquill and Gifford type). The multi-source, receptor version of the Alberta model was considered superior in many respects to the existing Ontario regulatory model and thus to be preferred.

Due to demand generated by widespread use of Pasquill-Gifford models, Environment Canada has developed the STAR (STability ARray) program to generate the simplified climatological input data used by these models. Typical input consists of frequency distributions of wind direction, wind speeds, and the Pasquill stability classes (A, B, C, etc.).

F.2.2 Ministry of the Environment's Models

In discussions with the Ontario Ministry of the Environment's Atmospheric Model Development Unit, during the early stages of this project, it was agreed that use of models currently under development in Ontario would be preferred. The models under development were far superior to the Pasquill-type models. The only relative shortcomings of the newer models were in the ease of use. For example, meteorological input data are in the form of detailed hourly meteorological observations. This represents a quantum leap in the quantity of data to be handled and gave rise to considerable complications in data transfer and data management.

A development version of the Ministry's multi-source, (GAS) model was released to the study team in early June. This helped

facilitate data conversion program development. A final "pre-public-release" version was released to the study team on June 21, 1988. That version was used to execute the modelling runs.

Some minor modification to the meteorological parameter calculation program (MET) provided by the Ministry was undertaken to flag additional meteorological cases as invalid (so these cases would not be calculated). Program and data conversion development are described in more detail in subsequent sections.

A full discussion of the new models is presented in Appendix H of the Clean Air Program Discussion Paper issued by the Ontario Ministry of the Environment in late 1987 (Environment Ontario, 1987).

F.3 SELECTION OF LOCATIONS

F.3.1 Introduction

To determine the public benefits of the proposed revisions to Regulation 308, it is necessary to determine the dispersion of emissions of each of the 96 specified contaminants emitted by each of the over 3,500 sources identified. In principle, each source must be modelled separately because the source characteristics and meteorological conditions are unique. In practice that is impossible due to lack of data and the magnitude of the effort it would require.

The availability of climatological information allows only a limited number of sites to be modelled; those for which the required input data can be compiled. The dispersion patterns modelled for those locations are then applied to all sources

within the area to which those climatological characteristics apply. This, in turn, requires that standard characteristics be assumed for the emission sources. The use of standard source characteristics is not a major concern since the required information is, with very rare exceptions, not available in any case. The source characteristic assumptions are discussed in Section F.5 below. Here we review the procedures used to identify the locations with different climatological characteristics.

F.3.2 Climatological Data Requirements

The Ministry's GAS model requires input climatological data from both hourly observing stations and upper air stations. There are no locations within the study area for which both hourly observations and upper air data are available. To get the model input required upper data from U.S. and Quebec upper air stations must be matched with data from Ontario hourly observing stations.

The process of selecting locations to be modelled starts with the list of hourly observing stations in Ontario and eliminates those that have similar climatological conditions. Appropriate upper air data are then matched to these remaining locations.

The Ministry's MET and GAS models require hourly air temperature, cloud opacity, wind speed and wind direction observations in addition to a daily snow on the ground indicator and mixing height, which is derived from upper air temperature profiles. Thus the starting point for the selection of locations is the 32 hourly observing stations in Ontario in the climatological archive of Environment Canada, Atmospheric Environment Service. Most of these stations have a data record extending for approximately 30 years. This is the typical period of record considered necessary for a useful climatological data set.

One year is composed of 8760 hours, so the analysis of four hourly weather elements for a 30 year period for all Ontario stations would require analysis of over 30 million observations. This was well beyond the scope of the project.

F.3.3 Approach to the Selection of Locations

To reduce the number of locations, and hence the computational work load, in a scientifically credible manner it is necessary to develop criteria to determine when stations have similar climatological characteristics from the perspective of the dispersion model.

An examination of the Ontario Ministry of the Environment's model indicated that the development of dispersion contours around a source depends heavily on the wind speed and direction of the source area. Accordingly, we began by comparing mean annual statistics of wind speed and direction for the 32 available stations.

Several stations are located very close to one another, and so allow us to define criteria for similar climatological characteristics. For example, Toronto Downsview Airport (latitude $43^{\circ} 45' N$, longitude $79^{\circ} 29' W$) or Toronto International Airport (latitude $43^{\circ} 40' N$, longitude $79^{\circ} 38' W$) could be used to represent conditions in the Toronto area. Similarly, either Ottawa Rockcliffe Airport (latitude $45^{\circ} 27' N$, longitude $75^{\circ} 38' W$) or Ottawa International Airport (latitude $45^{\circ} 19' N$, longitude $75^{\circ} 40' W$) could be used to represent conditions in the Ottawa area. It follows that if other geographically proximate stations had wind statistics as similar to one another as these station pairs, then they too could be considered interchangeable for the purposes of this study.

F.3.4 Wind Speed and Direction Comparisons

Stations were first compared by examining the average annual frequency of occurrence of each wind direction (8 point compass) and calm conditions. Each of these nine values for one station in a station pair was subtracted from the corresponding value for the other station to obtain their difference. The largest difference across these nine values was then selected to represent the maximum departure of each station from the other in terms of wind direction frequency. For the two Toronto stations, the largest difference occurred for northerly winds which are observed 17 per cent of the time at the International Airport as opposed to 11.7 per cent of the time at the Downsview Airport for a difference of 5.3 per cent (Environment Canada, 1982). The corresponding value for the two Ottawa stations was 3.4 per cent. These values are given in Exhibit F.1 along with similar values for all possible station pairs in Ontario.

Wind speed characteristics were compared by examining average annual wind speed values by direction (8 point compass). Again the largest difference among the eight wind speeds was selected to represent the maximum departure of each station from the other for each station pair. These values are given in Exhibit F.2 for all Ontario station pairs. For the two Toronto stations the maximum wind speed difference was 2.7 km/h, while the corresponding value for the Ottawa stations was 3.4 km/h.

F.3.5 Selection Criteria

From these examples we concluded that stations could be considered to be essentially similar for dispersion modelling purposes if their maximum wind direction difference was less than 5 per cent and if their maximum wind speed difference was less than 3 km/h. This rule is, if anything, too stringent since

EXHIBIT F - 1

WIND DIRECTION

Maximum Difference for the 8-Point Compass Plus Calm (% Frequency)

	ATLCO	TROUT	EARLY	GERAL	COPE	KAPUS	LEFOR	KINGS	LANSO	ORNO	MOSSO	MT	FORNISO	N	RAY	OTT	A	OTT	N	PETAN	PICEL	NEL	L	SAULI	SINCO	SIOU	SUBNO	THUND	TIME	TOR	O	TOR	A	TRENT	WANA	WERT	WINDS	WIN	
	9.7	8.6	4.3	4.15	4.1	8.75	9.45	9.55	11.8	6.7	8.6	7.75	8.2	11.9	8.75	10.45	4.85	8.2	10.4	13.45	8.9	4.5	9.7	9.9	7.5	9.35	7.2	12.45	10.4	7.45	12.9	4.3							
	18.5	12.4	10.7	14.1	18.2	18.5	16.7	20.7	15.9	10.2	11.6	12.9	11.9	14.9	18.5	13.1	7.0	15.8	20.5	11.0	16.3	13.8	10.4	12.3	13.8	13.1	18.9	11.7	8.0	15.5	18.5	7.8							
LAKE	8.1	8.3	5.3	3.55	7.45	9.35	7.3	5.15	3.75	4.9	5	9.3	4.85	7.15	10.7	7.3	3.8	11.7	7.55	5.1	8.35	8.85	5.1	5.4	3.45	7.3	25.2	7	8.75	3.75									
	9.8	7.15	3.8	6.25	11.2	8.3	9.85	7.45	8.45	8.85	11.15	9.75	9.55	7.45	9.15	8.1	18.1	12.8	5.45	8.2	11	5.3	7.7	7.15	8.45	19.1	8.85	10.8	3.8										
	3.9	7.5	8.3	8.5	12.4	5.85	6.16	7.7	8.2	8.3	5.76	8.6	5.4	12.25	12.2	8.1	7.55	3.2	7.05	8.2	4.4	8.7	7.35	18.9	5.3	7.8	3.9												
	5.2	5.75	5.4	10.15	4.9	4.1	8.95	5.9	7.35	4.45	9.1	7.95	3.85	10.7	10.8	7.15	8	5.85	7.05	4.85	3.8	8.16	7.9	20.8	3.1	8.25	3.1												
	3.9	8.8	9.3	8.45	4.45	6.35	5.1	8.45	8.35	8.16	8.4	8.85	8.85	14.7	8.8	4.48	8.3	9.6	2.8	8.1	4.8	7.5	22.9	8.55	8.3	2.8													
	7.75	12.7	7.8	6.85	8.3	8.6	7.85	8.35	11.5	12.1	8.85	11.3	13.35	12.45	5.35	5.2	13.4	4.9	8.3	8.7	11.4	75.2	5.4	8.85	4.9														
	14.2	8.1	6.85	8.85	8.8	7.4	8	11.15	11.15	5.5	13.4	14.35	8.1	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55	13.05	8.7	4.55
HOUSE	10	7.35	9.55	10.45	14.15	8.2	9.2	12.9	12.15	7	12.2	9.85	9.5	11.2	11.5	10.45	8.4	10.75	9.8	7.4	11.45	13.8	7																
	4	4.5	8.55	7.1	7.8	5.15	8.75	5.85	10.55	7.45	5.95	5.8	7.7	5.5	7.8	2.8	8.2	5.25	22.8	8.55	5.35	2.8																	
	8.8	7.9	8.8	3.9	5.1	10.4	4.8	12.7	10.25	8	8	5.2	8.3	5.2	5.1	5.7	6.5	24.9	4.5	8.25	3.9																		
EST	8.3	8.3	5.2	7.85	8.45	4.5	8.9	10.75	8.5	5.45	8.9	9.75	7.2	4.8	9.4	7.75	18.3	4.9	8.95	4.5																			
	10.25	8.55	9.25	10.1	8.55	8.55	12.8	8.2	4.1	8.9	10.45	5.75	5.95	10.4	8	11.25	4.1																						
	7.7	9.5	12.45	8.85	13.05	11.15	10.45	9.8	4.1	8.05	8.85	6.75	8.2	8.7	25.1	5.7	8.1	4.1																					
	3.4	10.8	5.55	12.35	7.9	5.85	8.45	7.8	5.05	7.7	3.4	8.3	5.15	23.2	5.75	5.4	3.4																						
SCULPTE	11.3	9.45	14.05	9.9	8.15	8.35	10.1	4.55	9.15	5.3	10.8	4.55	19.8	8.3	8.4	4.55																							
	8.75	12.7	9.7	10.5	11.8	11.75	9.75	10.2	9.45	13	14.5	8.9	13.45	8.75	3.75	3.75																							
NE	11.05	11.9	4	5.9	8.4	7.55	7.2	3.75	8.2	5.55	22.3	4.75	4.7	3.75																									
	12.2	19	7.35	10.1	14.5	10.55	12.95	9.9	13.9	27.2	10.75	12.5	7.35																										
WHITE A	12.2	11.4	13.05	8.2	14.05	8	12.5	11.7	18.4	12.1	12.15	8.2																											
	9.5	10.8	8.85	11.2	7.5	8.5	7.85	25	8.25	7.7	8.95																												
SHOOT A	8.25	9.8	5.85	8.25	8.4	10.15	20.5	5.35	10.8	5.35																													
	9	5.8	8.3	8.45	7.3	28.1	8.3	8.7	5.8																														
WAT A	11.05	5.9	9.2	8.75	19	10.2	8.3	5.9																															
	5.95	8.35	9.05	20.3	4.8	7.05	4.8																																
CONVENT	5.3	4.95	19.8	5.1	5.4	4.95																																	
WATL A	8.45	23.8	8.8	7.2	8.45																																		
	18.4	8.2	8.3	8.3																																			
	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2	22.2	23.2			
	5.25																																						

Maximum Difference for the 8-Point Comparison in km/hr.

ALTIQ	TROUT	EARLE	CEPAL	CODE	APPU	KENOR	ELINGS	LAKES	LORDO	MOSSO	MT	COMMISSO	N	BAY	OIT	A	OTI	N	PITAN	PIECL	RIO	I	SAULT	SIMCO	SILOUS	SUDBO	THUDO	TIMPA	TOR	O	PRENT	WANA	WAPAT	MIQOS	WIT	
ARMSTRONG	5.04	5.53	6.02	3.32	7.35	3.12	5.54	8.75	2.80	0.15	3.33	4.47	3.48	5.08	5.16	4.68	7.55	4.08	5.18	7.60	4.16	7.08	12.87	4.50	5.31	5.55	5.83	5.81	5.84	7.04	8.78	2.04				
ATLANTIC	7.66	8.73	9.89	8.03	7.80	11.17	6.41	0.81	7.12	6.19	7.80	7.02	3.92	4.82	2.82	11.13	8.87	4.89	16.58	7.95	7.00	8.41	8.49	10.08	3.54	11.23	9.52	2.82	2.82	2.82	2.82	2.82	2.82	2.82		
BIG TROUT LAKE	5.25	4.53	6.97	3.80	3.21	5.45	5.14	4.49	3.57	3.10	2.51	3.97	8.45	6.35	8.31	10.05	5.08	5.38	3.77	9.23	1.88	3.78	3.77	4.05	3.34	4.48	7.14	5.14	1.10	1.10	1.10	1.10	1.10	1.10		
EARLETON A	4.42	3.03	3.21	2.99	3.33	5.37	2.55	5.58	2.88	5.07	3.43	4.45	5.88	6.24	6.81	10.13	4.30	3.40	5.62	7.28	7.05	4.12	2.35	4.05	3.14	9.22	2.80	3.23	7.15	7.15	7.15	7.15	7.15	7.15		
GERALTON	5.48	2.89	4.89	6.50	4.00	8.12	3.48	4.44	4.82	5.08	5.12	4.35	4.00	4.91	7.07	7.72	3.62	3.81	11.27	7.55	3.50	5.82	8.00	6.05	9.07	5.68	8.84	2.89	2.89	2.89	2.89	2.89	2.89	2.89		
GORE BAY A	8.03	6.23	2.75	7.31	3.34	7.10	4.40	3.39	6.57	6.59	8.00	6.58	6.15	11.41	6.41	7.18	7.17	6.28	3.88	6.19	3.22	9.45	3.73	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	
KAPUSKING A	3.02	6.63	3.48	5.24	3.47	3.45	2.97	4.73	4.81	3.88	4.71	0.82	6.15	7.83	3.43	10.48	4.35	2.90	5.04	4.92	5.70	7.38	5.19	5.38	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83		
LEONORA A	4.48	5.30	3.37	5.88	2.98	3.24	3.95	4.47	7.01	6.30	7.13	3.29	5.97	4.58	5.83	9.82	4.04	4.70	4.37	3.58	7.34	5.45	5.45	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80		
KLINGSTON A	9.10	4.38	9.09	8.19	7.14	7.18	7.90	0.03	9.51	10.34	12.50	7.81	5.14	9.04	6.07	9.51	7.85	8.80	7.58	10.30	1.71	4.84	4.84	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	
LANSBORNE HOUSE	4.73	3.25	3.19	2.58	4.35	3.91	5.15	4.32	4.53	4.80	6.07	4.50	4.32	5.22	12.79	4.73	5.22	4.72	4.73	3.23	8.00	7.40	7.40	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	
LONDON A	4.83	1.81	5.58	3.75	3.81	5.28	8.00	8.45	8.13	4.08	4.08	5.81	5.52	6.93	5.71	3.27	3.20	2.85	6.85	2.87	3.43	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	
MOOSEHOLE	3.35	4.59	2.43	2.49	2.37	5.28	4.98	1.65	5.58	5.08	2.42	9.58	3.40	2.78	4.21	4.08	6.08	6.34	7.46	5.53	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	
MOUNT FOREST	3.59	2.48	3.43	4.14	4.32	6.77	7.19	5.82	3.49	6.23	9.80	5.38	4.09	1.48	1.94	3.58	4.09	4.81	3.58	4.76	4.06	3.24	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	1.48	
MUSKOGA A	3.03	4.07	6.74	4.5	6.12	6.87	1.70	5.80	3.42	10.52	4.53	3.68	4.71	4.81	7.17	6.16	8.16	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	
NORTH BAY A	3.17	4.95	8.80	7.38	9.35	7.91	2.98	4.85	8.04	4.73	4.71	3.02	3.71	5.80	6.71	5.45	6.01	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	2.89	
OTTAWA A	3.40	5.59	1.44	6.51	4.74	3.71	4.91	8.88	3.47	4.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	2.71	3.10	
OTTAWA ROCCELLE	4.53	4.55	6.54	4.71	7.49	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	3.71	6.89	
PETANAWA A	2.14	8.14	7.43	8.38	3.58	11.98	4.58	4.71	8.40	6.78	7.59	8.31	8.73	7.93	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	2.14	
PICCLE LAKE	5.57	7.11	6.40	2.71	11.87	8.38	4.30	4.30	8.25	8.13	7.25	8.35	8.40	8.75	7.01	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	
BRED LAKE	10.07	7.38	6.58	17.39	8.83	9.82	8.73	8.13	10.23	8.38	9.82	8.73	8.13	10.23	8.38	9.82	8.73	8.13	10.23	8.38	9.82	8.73	8.13	10.23	8.38	9.82	8.73	8.13	10.23	8.38	9.82	8.73	8.13	10.23	8.38	9.82
SAULT STE MARIE A	5.80	7.28	9.70	5.41	5.07	4.82	5.08	4.00	13.52	8.43	5.18	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
SILOUS	5.75	10.48	7.18	4.08	3.88	3.74	3.58	7.71	4.12	4.57	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	3.58	
SILOUS LOOKOUT A	10.80	4.07	3.23	5.71	5.59	8.71	6.27	8.11	8.11	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	
SUDBURY A	11.03	7.53	6.85	9.37	9.40	14.43	9.88	0.09	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	6.05	
THUNDER BAY A	3.89	5.58	6.16	8.14	10.24	9.53	7.54	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	3.89	
TIMMINS A	5.57	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	5.45	
TORONTO DOWNSVIEW	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	
TORONTO INTL A	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	
TRENTON A	8.80	2.86	3.37	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84	
WANA A	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	8.79	
WAPATOSK A	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	

neither the Toronto stations nor the Ottawa stations would qualify as essentially similar according to our criteria.

F.3.6 Selection of Locations

Four geographical areas were found to contain "essentially similar" stations that met or almost met the similarity criteria defined above. These areas included northwestern Ontario, northeastern Ontario, Georgian Bay and southwestern Ontario. Plots of average annual wind direction occurrence and average annual wind speed by direction for the candidate stations in these regions are given these regions in Exhibit F.3 through F.6, respectively. The two stations in Georgian Bay and Southwestern Ontario obeyed the similarity rule completely.

In northeastern Ontario, Timmins Airport and Kapuskasing Airport were essentially similar according to the rule while the Timmins Airport/Earlton Airport pair (5.3 per cent and 4.12 km/h) and the Earlton Airport/Kapuskasing Airport pair (3.8 per cent and 3.21 km/h) did not. In northwestern Ontario, Armstrong Airport was the station most closely approximating the four others in this group, but only the Armstrong Airport/Sioux Lookout pair were essential similar according to our selection rule.

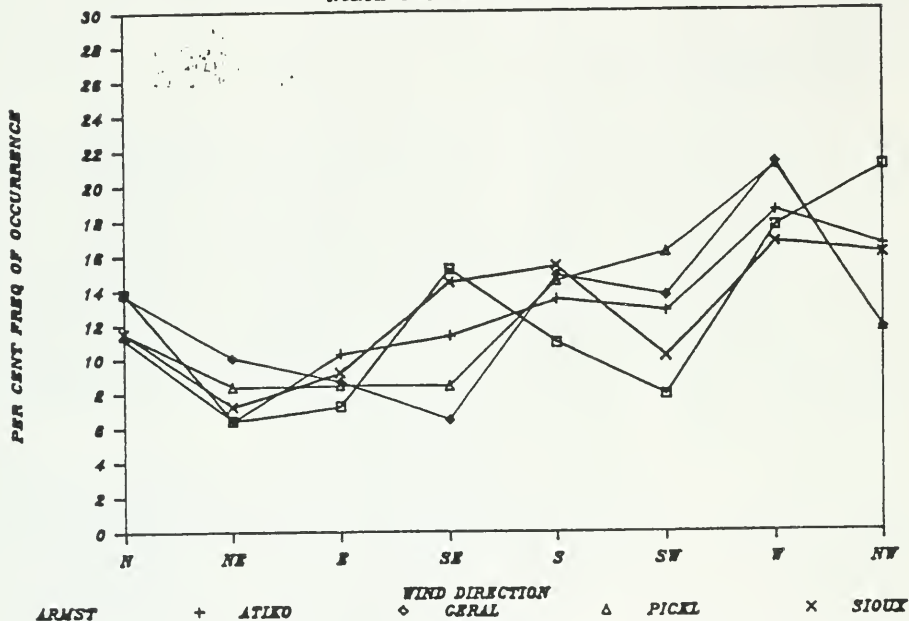
Despite the fact that some northeastern stations and most northwestern stations had differences larger than was specified by the criteria of essential similarity, these stations are located in regions with very few establishments in the economic sectors being studied. Hence the use of additional dispersion patterns in those regions was not justified, despite the slightly larger dissimilarities.

The amalgamations adopted based on the procedures described above are as follows: (the representative station is underlined);
Toronto (Toronto International Airport, Toronto Downsview

Wind Correlations-Northwestern Ontario

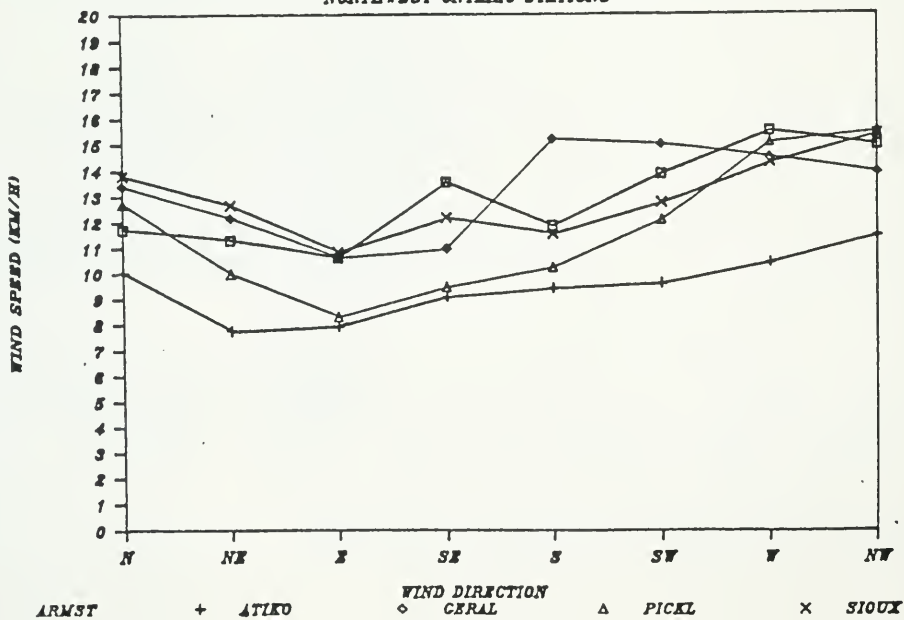
WIND DIRECTION OCCURRENCE

NORTHWEST ONTARIO STATIONS



AVG WIND SPEED BY DIRECTION

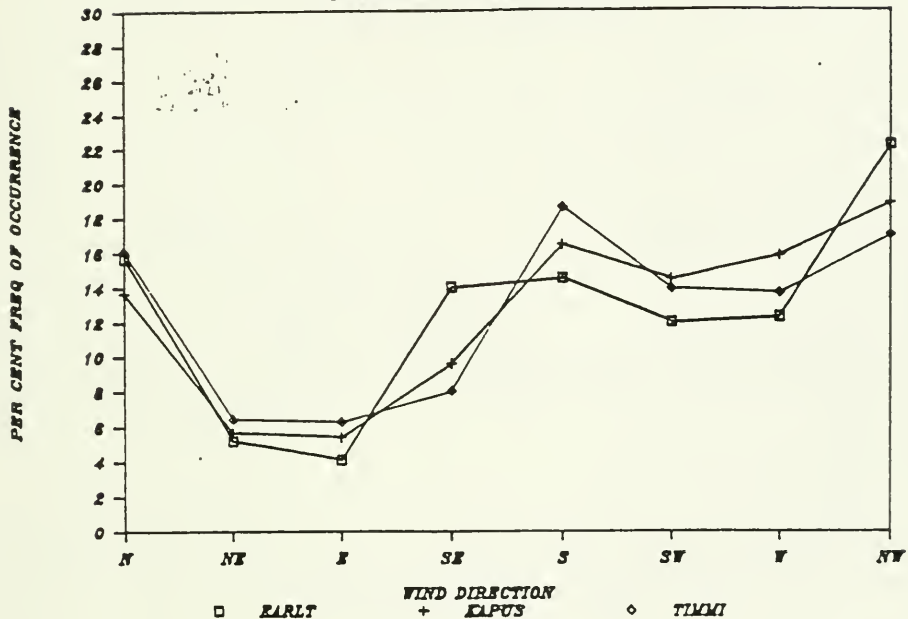
NORTHWEST ONTARIO STATIONS



Wind Correlations-Northeastern Ontario

WIND DIRECTION OCCURRENCE

NORTHEAST ONTARIO STATIONS



AVG WIND SPEED BY DIRECTION

NORTHEAST ONTARIO STATIONS

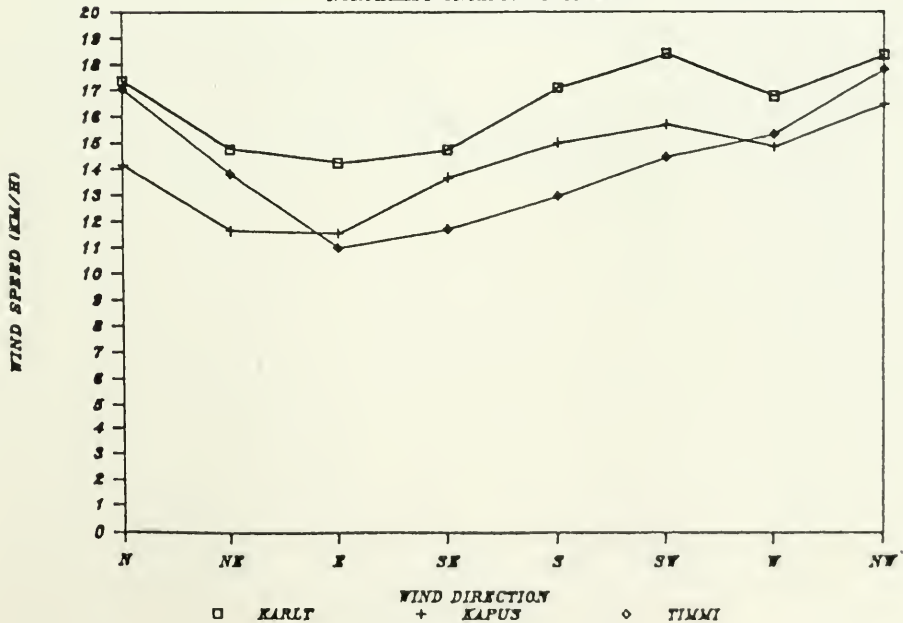
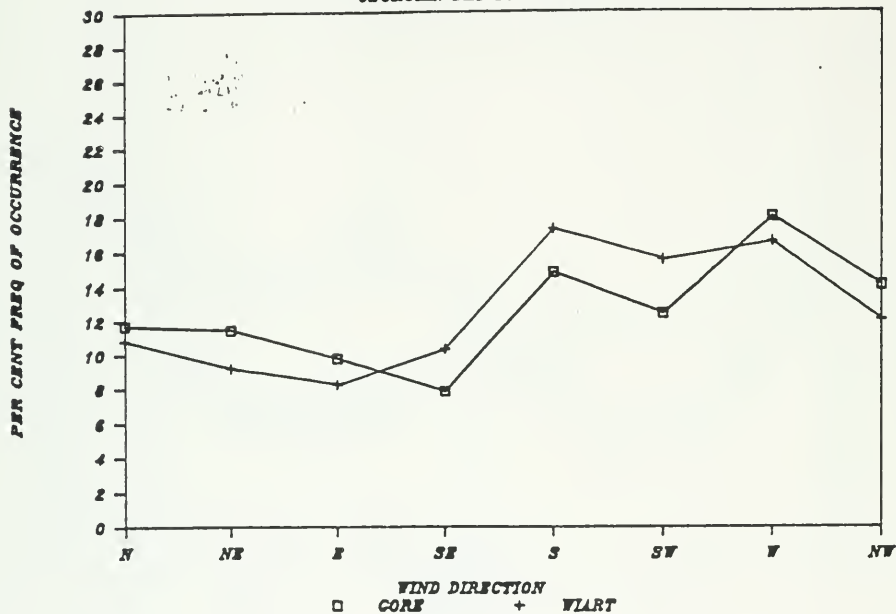


EXHIBIT F - 5

Wind Correlations-Georgian Bay

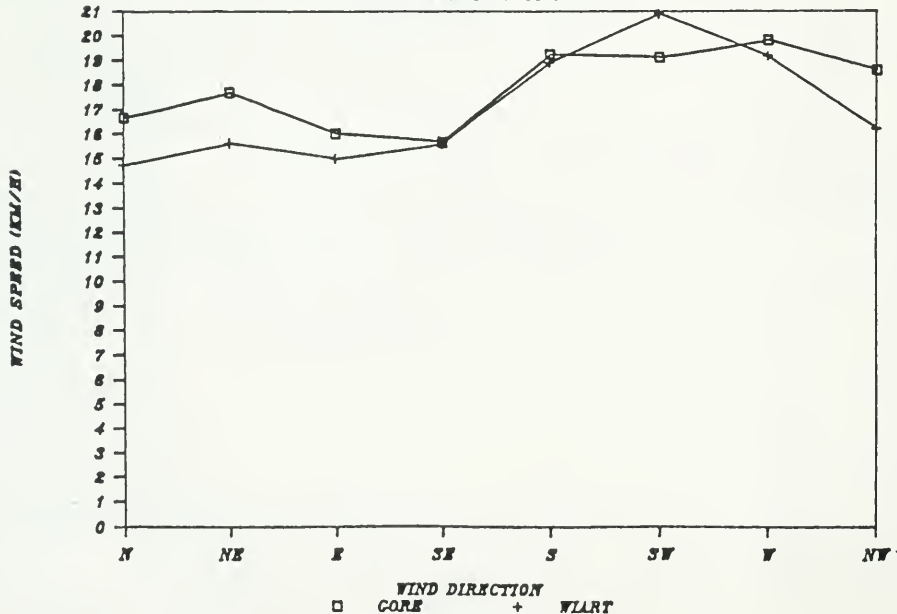
WIND DIRECTION OCCURRENCE

GEORGIAN BAY STATIONS



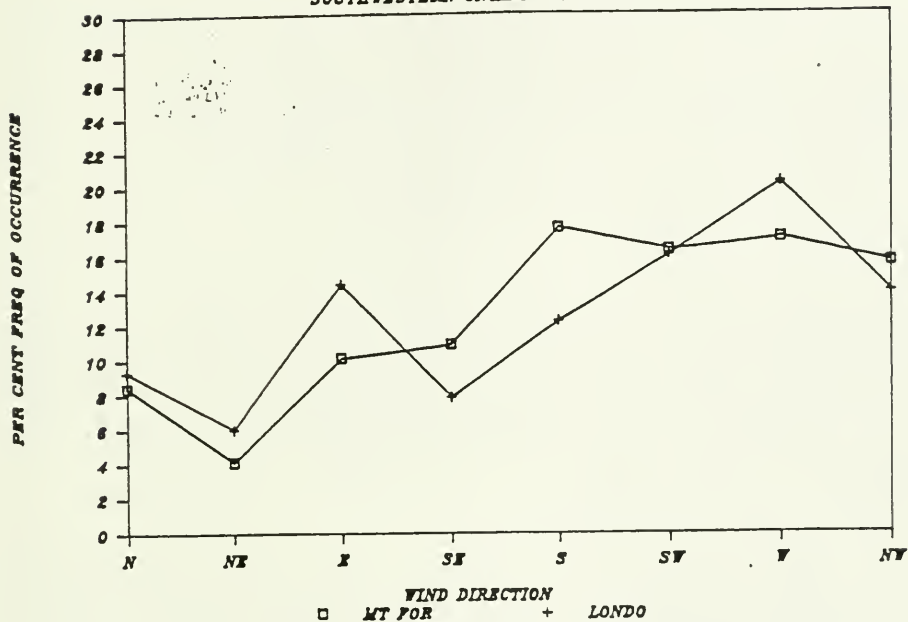
AVG WIND SPEED BY DIRECTION

GEORGIAN BAY STATIONS

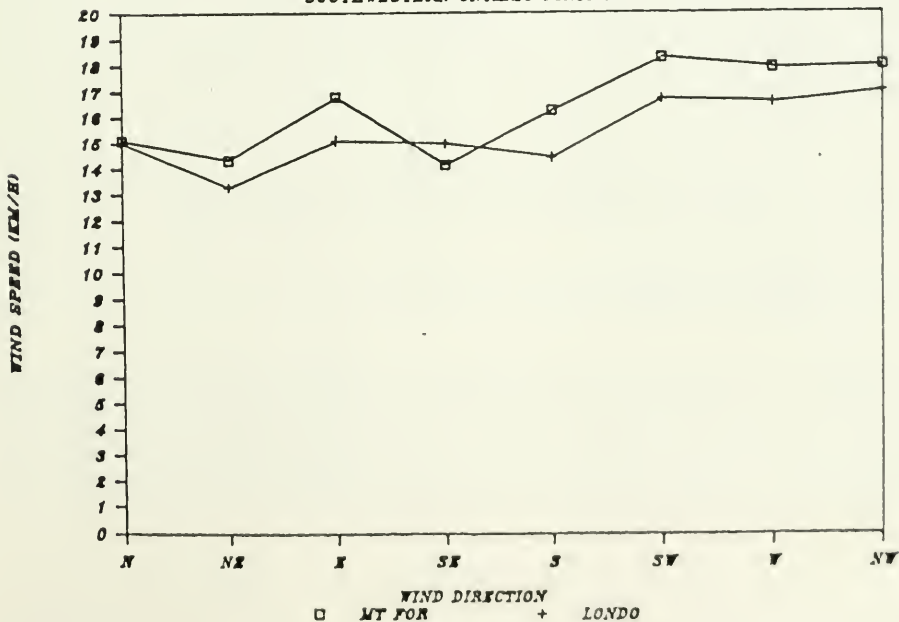


Wind Correlations-Southwestern Ontario**WIND DIRECTION OCCURRENCE**

SOUTHWESTERN ONTARIO STATIONS

**AVG WIND SPEED BY DIRECTION**

SOUTHWESTERN ONTARIO STATIONS



Airport), Ottawa (Ottawa International Airport, Ottawa Rockcliffe Airport), Northwestern Ontario (Armstrong Airport, Atikokan, Geraldton, Pickle Lake, Sioux Lookout), Northeastern Ontario (Timmins Airport, Earlton Airport, Kapuskasing Airport), Georgian Bay (Wiarton Airport, Gore Bay Airport), and Southwestern Ontario (London Airport, Mount Forest). These amalgamations resulted in the removal of 10 stations from the data base.

Eight additional stations were also removed since they are not in areas with significant sources of the contaminants studied in this project. These stations are Armstrong Airport, Big Trout Lake, Lansdowne House, Moosonee, Muskoka Airport, Petawawa Airport, Red Lake Airport, and Wawa Airport. Any sources examined in these regions use more distant stations to define average meteorological conditions.

The stations retained, which together are taken to define the meteorological conditions for the province, are Kenora Airport, Kingston Airport, London Airport, North Bay Airport, Ottawa International Airport, Sault Ste. Marie Airport, Simcoe, Sudbury Airport, Thunder Bay Airport, Timmins Airport, Toronto International Airport, Trenton Airport, Wiarton Airport and Windsor Airport.

F.4 COMPILATION OF METEOROLOGICAL DATA

F.4.1 Need to Select a Representative Year

While the rationalization of observing stations to be included in the analysis reduced the data to be analyzed by more than 50 per cent, the data burden was still too large for the project. To accomplish a further reduction it was decided to replace the

30 year period of record used to characterize meteorological conditions with a representative year that closely approximates the 30 year period. This representative year yields an annual dispersion field very close to that obtained from the 30 year history for each of the 14 stations.

For the purposes of the project only annual statistics summarizing the dispersion pattern are required, the large number of hourly observations in one year ensure that statistics derived from these hourly observations do not vary greatly from year to year. Consequently, any year in the data base could be used to represent typical conditions if all input data were hourly observations. Such, however, is not the case.

F.4.2 Snow Cover

Specifically the presence or absence of snow on the ground is not subject to the law of large numbers in the way that hourly observations are. The period of time that snow is present for any station varies a great deal from year to year. In the Ministry's model the presence of snow on the ground is assumed to reflect all short wave radiation back into space, with the result that convective conditions cannot occur (Ontario Ministry of the Environment, 1987). The disallowance of convective conditions for an unusually long or unusually short period relative to the 30 year average may well result in a significantly different dispersion field. Accordingly, it was decided to seek a single year which, for all 14 stations, the winter snow cover period was as close as possible to the average obtained using the entire period of record for the station.

The time period for which snow was on the ground for at least seven consecutive days was determined for each of the 14 stations for all years of each stations's climatological record. Significant year to year variability was found. For example, in

Kenora a 30 year data base indicated that on average seven consecutive days of snow cover began on November 11 and ended on April 11 for a total of 152 days. However, in 1968 snow was present for only 126 days while in 1965 snow was present for 179 days. Other stations showed similar variability in terms of the length of the snow cover season.

F.4.3 Selection of the Representative Year

Only one year, 1986, had the time with snow on the ground within one standard deviation of the long term average for all 14 stations. Thus 1986 was selected as the representative year for the calculation of average annual dispersion statistics.

F.4.4 Compilation of Climatological Input Data: Hourly Station Data

Hourly meteorological observations for the representative year for each of the 14 centres (totalling 500,000 observations) were purchased from the Canadian Climate Centre, Atmospheric Environment Service and formatted for input to the Ministry's METCO program.

The METCO program, provided by the Ministry, allows the use of data formatted for use in the single source GAS model in the newer multi-source, multi-receptor version of the model. The program also allows disabling of upper air wind speeds where desirable.

This program was used as the basis for a general conversion program (METCOR) written by the study group to automate the interface of Environment Canada Surface Data, U.S. and Canadian Upper Air Data, the snow record, data decision-making, flagging and reformatting of input data. The METCOR program produced 14 complete records for the representative year, ready for input

to the Ministry's MET program (meteorological parameter calculation program). These 14 records represent average meteorological conditions for the Province of Ontario for the period 1957 to 1986 inclusive. The MET program generates the meteorological parameters required as input by the dispersion (GAS) model.

F.4.5 GMT Conversion

Canadian surface weather data are recorded in local standard time for each station. A program segment was written to convert local standard time (date) to Greenwich Mean Time (GMT) for input to the GAS model.

F.4.6 Cloud Cover

Canadian surface weather data expresses cloud cover and cloud opacity in 10ths. Cloud cover and cloud opacity affect the occurrence of convective conditions. Cloud opacity, where available, is the better determinator of convective conditions and was used in this study. A program segment was used to convert from 10ths to 8ths for input to the GAS model.

F.4.7 The Snow Record

The most significant determinators of convective conditions are the presence or absence of snow cover and the presence or absence of daylight. Most winters are characterized by alternating periods of "snow-on" and "snow-off". Wide swings occur, throughout the 30-year record, of starting and ending dates - dates of snow cover, and dates of bare ground. The snow cover period may also be interrupted by periods of bare ground.

The 30-year record for each centre was reduced to a mean start and end date of snow cover. The definition of snow cover used is

the period from which persistent (7-day duration), 2 cm snow cover was first recorded to its last recorded date. This definition had the effect of reducing the length of the snow season. The reduction in the length of the season offsets, to some degree, the increase in the number of "snow-on" days which result from calling the snow cover period "continuous".

The 30-year mean period was used as the "snow-on" period for the representative year. A program segment was written to automate snow cover distribution in the model.

F.4.8 Wind

Canadian surface wind speed is in units of km/hr. A program segment was written to convert this to m/sec for the GAS model. Calm conditions were assigned a wind speed value of 0 m/sec where no value was provided. The MET and GAS modules increase this to a 1.5 m/sec minimum in appropriate cases. Upper air wind speeds were disabled in the model.

F.4.9 Wind Direction

The representative year chosen, being recent, was available in 10 degree compass resolution and was thus compatible with the GAS model interpolation routine (wind direction ± 5 degree randomization). A program segment was written to multiply the AES compass (0 to 36) by 10. In Environment Canada format, 36 is North and 0 is calm. A program segment was written to reassign 36 to 0 for the GAS model. Initial 0 (calm) values were assigned the first previous non-calm wind direction.

F.4.10 Upper Air Data

No Canadian upper air stations exist in proximity to most

Ontario emission centres. Thus, it was necessary to obtain U.S. near-border data to use with Ontario surface data.

F.4.11 Mixing Heights: U.S. Locations

Mixing heights were purchased for the representative year from the U.S. National Climatic Data Centre in North Carolina. The U.S. computer program used, generates a.m. and p.m. mixing heights using upper air soundings combined with surface data for the same station (Doty, 1983). The normal U.S. practice is to combine surface data from the surface location of interest. However, since the surface locations of interest are all Canadian centres, this was not possible. The use of matching upper air/surface data for the same station was considered a reasonable compromise.

Twice daily, mixing heights for the entire year were obtained for Flint, Michigan; Sault Ste. Marie, Michigan; International Falls, Minnesota; and Buffalo, New York.

F.4.12 Mixing Heights: Canadian Locations

Since mixing heights cannot be purchased from Environment Canada for Canadian Upper Air Stations, raw soundings data were purchased. The only Canadian centre in proximity to the locations to be modelled is Maniwaki, Quebec.

Since Maniwaki, Quebec surface data were not purchased, Ottawa surface data were used with the Maniwaki upper air data to generate mixing heights. This is in accordance with U.S. practice. A program was written to adjust base temperatures for base elevations, determine maximum surface temperatures for each period, and calculate the elevation of intersection between the sounding temperature profile and the dry adiabatic lapse curve for each surface temperature maximum.

A linear interpolation routine was written to refine intersections which occurred between sounding elevations. Negative elevations were assigned a value of zero, which was flagged by the revised MET program for cases which would ordinarily be convective. In such cases, a zero mixing height resulted in an invalid MET case in the GAS model execution (i.e., no calculation).

Ottawa was chosen as the surface centre because it is geographically central to the area of Ontario for which Maniwaki, Quebec upper air data would be deemed representative (i.e., Timmins, North Bay, Ottawa, Kingston). Time and budget did not permit a centre-by-centre match of local surface and Maniwaki upper air data.

F.4.13 Missing Data Flags

In the case of missing meteorological data a flag value of IDATA = 999 was assigned. This generates an invalid MET case for the GAS run (i.e., no calculation for that case).

F.4.14 Negative or Missing Mixing Height Flags

In cases of negative or missing mixing heights, IDATA was assigned a value of 987. A short addition to the MET program was written such that if IDATA = 987 and meteorological conditions were convective, IFLAG would be assigned a value of 999 (an invalid case).

F.4.15 Limitations of the Meteorological Database

Some centres, despite catalogue indications, were found to have incomplete meteorological records. For example, in Simcoe, measurements were only available for weekday periods. Results of

modelling with such data are less reliable than results for more detailed input.

The use of Upper Air Data from geographically removed centres is a somewhat dubious procedure. However it is one that is without alternative since upper air stations are so rare. For example, using Buffalo upper air data for Toronto leads to questions of how representative upper air data for a centre on the east end of a lake is of another centre on the north shore of a different lake. Errors would occur only in the case of convective conditions and are estimated to yield an output variance, on an annual average, of no more than 5 to 10 per cent. The best centre, by this criterion, is Sault Ste. Marie, Ontario, since the Sault Ste. Marie, Michigan upper air station is so close to the Canadian surface weather station.

There are many surface stations in northwestern Ontario. Kenora was chosen to represent this area based on its population density. It is estimated that this choice would affect the dispersion of pollutants in other centres (e.g., Armstrong) to a smaller degree (5 to 10 per cent). It was not expected that large concentration excursions would occur and none were observed.

The dispersion model (GAS) does not deal with calm conditions "as are" but rather increases wind speed to 1.5 m/sec. for applicable cases. In addition, Environment Canada merely flags wind direction in calm cases (since by definition of calm, there is no wind to have a direction). To mesh what the model does, with what the source data doesn't provide, a wind direction was assigned in each case of calm. The choice of direction was that of the first previous "non-calm" wind direction. This perturbs the short term wind direction statistic less than introduction of an artificial randomization function. The frequency of occurrence of calm conditions is estimated at less than

2 per cent, so the impact of this assumption on results considered to be small.

F.5 EMISSION SOURCE CHARACTERISTICS

The GAS model requires, in addition to climatological data, input with respect to emission source characteristics. The characteristics of the several thousand emissions sources are, with very rare exceptions, not known. Hence these characteristics must be estimated. Since each of the 14 dispersion patterns could be applied to several hundred sources, the estimated characteristics should be typical of the variety of industrial establishments emitting the contaminants.

F.5.1 Building Sources

Of the several thousand commercial emissions sources in Ontario subject to the proposed revisions to Regulation 308, by far the most numerous are building sources. Such sources are generally defined as sources from which fugitive emissions emanate or stack emissions emerge at elevations less than twice the height of the building.

To precisely model emissions from such sources the exact dimensions of the building and the stack must be known. In cases of complex building shape (i.e., non-rectangular) or complex vicinity (i.e., larger buildings or variable terrain) mathematical modelling is inappropriate and physical modelling is preferred. Physical modelling is not possible for this analysis. Hence it is necessary to assume that all buildings are isolated, rectangular buildings with a stack less than twice the height of the building.

For this study, no information was available on building or building-stack dimensions for any source. To estimate ambient concentration, each source was assumed to be a building of 7 m height and 100 m width with a stack of less than 14 m elevation, emitting pollutants at 0 velocity and at ambient exit temperature. Such a building is a typical "industrial park" source. This assumption leads to very high ambient concentration uncertainties (i.e., order of magnitude) within 500 m of the source for source buildings of other configuration but is a far better source assumption than a zero elevation emitter. Reasonable concentration estimates beyond 500 m are achieved.

Since no data were available on individual elevated and buoyant (exit temperature above the ambient temperature) elevated source characteristics, such sources have been represented as building sources. The limitations of this approach are discussed in the next section.

F.5.2 Implications of the Assumed Building Source Characteristics

If an emission is ground-based, the building source assumption will yield artificially high initial dilution within 500 m of the origin. If an emission is elevated, and possibly buoyant, the building source assumption will yield artificially high concentrations within 500 m of the source. If the source is less than about 30 m in elevation and of moderate buoyancy, beyond 500 m concentrations will generally fall within the same order of magnitude with the highest discrepancies found at the perimeter (near the zero concentration area). In general, the higher and hotter the source, the larger the discrepancies.

Distribution inaccuracies resulting from the assumptions can be illustrated by the fact that the worst case meteorology for an

elevated source occurs under convective atmospheric conditions, whereas the worst case meteorology for a building source occurs under stable atmospheric conditions. This type of possible inaccuracy contributed to the decision to use concentration averages of 8,760 hourly meteorological cases rather than averages over shorter time frames. Where sources approached the characteristics of the "typical building source" the accuracy of the annual average would be unassailable. In other cases, the annual average would have a "smoothing" effect where periods of larger differences would be offset to some degree by periods of smaller differences yielding a better estimate of average concentration. This minimizes the limitations of these source assumptions.

F.5.3 Elevated Sources

Elevated sources, by definition, emit beyond twice the elevation of the highest part of an attached or adjacent building. Depending on the stack exit temperature the emission plume may be more or less buoyant than the surrounding air. Accurate modelling requires that all of the stack parameters be known. These parameters are: stack height, exit diameter, exit velocity, exit temperature (and emission rate).

Such information was not collected for any source in Ontario as part of this study. In addition, the use of the proposed new Ontario models entirely precluded use of individual source information of any kind. If one took 2,000 sources for example, and ran one year's meteorology, using an IBM-AT with math-coprocessor, 36,000 hours of computer time would have been required (i.e., 4.1 years).

F.5.4 Near-Lake Sources

Discussions with Ministry staff led to consideration that lakeshore effects should be dealt with in modelling certain sources.

Predominant sources to which lakeshore effects would most often be encountered were identified as Lakeview Generating Station in Mississauga, and Nanticoke Generating Station. The present development version of the Ministry's proposed Lakeshore Model has not been integrated with the general GAS model. Such integration is necessary because a lakeshore effect can only occur under specific conditions which will only arise at certain times during the year. At other times dispersion would occur as per the GAS model.

We endeavoured to perform the model integration; however, the project budget was exceeded as a result and this work remains incomplete. Hence, lakeshore effects are not included in the output of this study.

The error involved in ignoring lakeshore effects for these two sources would be an under-estimation in the range of 1 to 3 times of annual average concentrations within 3 km onshore from these two sources.

F.6 THE RECEPTOR GRID

The Ministry's grid-generator program RECGEN was used to generate a receptor grid network from 0 to 24 km of 2 km resolution. A finer grid of 500 m and 1,000 m grid points was superimposed on

the coarse grid to permit better resolution in the near-source area where most of the impact of building sources is felt.

The GAS model calculated running average (annual average in this study) concentrations for each receptor point (grid coordinate). A surface roughness of 1.0 m and a receptor elevation of 0.0 m was used in all cases.

Due to the assumptions relating to source characteristics the resulting ambient concentrations within 500 m are most uncertain. As an approximation, where receptor grids intersect/overlap (for different sources), if the source is known to be elevated the within-500 m area could be taken to be of zero concentration. Where the source was not known to be elevated, the within-500 m area could be taken to be of concentration equal to that at the 500 m boundary. The alternative would be to ignore all areas of overlap within 500 m of the source (which in the case of Toronto might mean ignoring most of the city for some pollutants).

Fourteen dispersion patterns were generated; one for each location selected. The source characteristics are assumed to be the same for all 14 patterns. An emission rate of 1 gram/sec is used in each case. Since the model is linear with respect to dispersion, the calculated concentration at each grid coordinate is scaled by the emission rate for the specific source. For example, if the concentration at twelve kilometers due east of the source is calculated by the model to be 0.0158 micrograms/cu.m. and a given source emits a contaminant at a rate of 5 grams/sec then the ambient concentration twelve km due east of that source will be 0.0790 micrograms/cu.m.

F.7 QUALITY ASSURANCE

F.7.1 Input Quality Control

Considerable processing, conversion, and flagging of data were required prior to running the dispersion model. Conversion, processing, and flagging programs were all validated manually using Toronto and Simcoe meteorological data. MET program output (GAS program input) was reviewed in detail (i.e., for the entire one year hourly record) prior to GAS program execution. Byte volumes of records for other centres were compared for consistency and random hourly records were inspected for other centres.

All centres used the same input files, except for meteorological data where individual centre files were used. To maintain file control, all non-.MET files (i.e., .RUN, .FUN, .REC, .SRC and blank .AVG files) were located in a write-protected directory. A DOS batch-program was written which transferred these files (renamed) to the execution directory, prompted for the correct .MET file, verified the presence of these files, and executed the GAS model program.

F.7.2 Output Quality Control

The number of valid and invalid (uncalculated) MET cases was inspected on completion of each run and compared with the prior knowledge of the relative occurrence of missing and flagging data. Exhibit F.7, the Run Record, illustrates this.

All output (.AVG) files were imported to a LOTUS Symphony file, compressed, and compared. The coordinates of the maximum concentration receptor were inspected in each case.

THE RUN RECORD

Name of Centre	Filename	Upper Air Station	Hours Difference from GMT	Snow **	No. of Valid MBT Cases	No. of Invalid MBT Cases
Kingston	KIN	Maniwaki, Que.	5	12-19	5736	3024
Kenora	KEN	Int'l. Falls, MN	6	11-11	8714	46
London	LON	Flint, MI	5	12-10	8609	151
North Bay	NOR	Maniwaki, Que.	5	11-21	8709	51
Ottawa	OTT	Maniwaki, Que.	5	12-02	8405	355
Simcoe	SIM	Buffalo, NY	5	12-15	6662	2002
Sault Ste. Marie	SOU	Sault Ste. Marie, MI	5	11-24	8630	130
Sudbury	SUD	Sault Ste. Marie, MI	5	11-22	8631	129
Sudbury, Inco*	SUDINCO	Sault Ste. Marie, MI	5	11-22	8631	129
Thunder Bay	THU	Int'l. Falls, MN	5	11-25	8700	60
Timmins	TIM	Maniwaki, Que.	5	11-12	8736	24
Toronto	TOR	Buffalo, NY	5	12-15	8656	104
Trenton	TRE	Buffalo, NY	5	12-17	8662	98
Warton	WIA	Flint, MI	5	12-03	8585	175
Windsor	WIN	Flint, MI	5	12-28	8590	168

*Elevated Source, all others are Building Sources.

**30-year average dates for persistent (2cm, 7-day), snow cover.

The relative concentrations of the maxima were compared. With each centre using the same building source and unit emission rate, the maxima should be within the same order of magnitude. In addition the concentrations at every grid point were summed for each centre and the sums compared between centres. This test on distribution should also yield results in the same order of magnitude.

All of the above tests were passed. Exhibit F.8 presents the first page of this summary file as an example.

A DOS batch program was written to copy the appropriate files to diskette for back-up and to save output files to the appropriate directory. The DOS programs ensured that file integrity was maintained during movement and handling.

F.8 REFERENCES

Doty, Stephen R., 1983. Climatological Aids in Determining Air Pollution Potential, U.S. National Climatic Centre. 26 pp.

Environment Canada, Atmospheric Environment Service, 1981. Climatological Station Data Catalogue, Ontario. 125 pp.

Environment Canada, Atmospheric Environment Service, 1982. Canadian Climate Normals, Volume 5: Wind. 1951-1980. 283 pp.

Ontario Ministry of the Environment, 1987. Air Pollution Regulation 308, Appendix H: Air Pollution - General Regulation Modelling Proposals. 170 pp.

ONTARIO AMBIENT CONCENTRATIONS - Annual Averages from Proposed REG-304 Model

	KEN	LOW	SIN	SOD	SUD	SUDINCO	THU	TOR	YRE	VIA	WIN	OTT	MOR	KIN	YIM
MAXIMUM CONCEN:	6.447	5.741	3.430	10.459	7.439	0.00048	11.232	6.496	6.431	8.061	4.266	6.837	6.195	4.197	13.376
SUM OF GRIDS:	51.493	50.134	21.270	50.676	50.524	0.13700	56.513	40.570	60.209	65.652	40.170	53.091	59.257	31.764	86.847
I	I														
-1000	-1000	0.557	0.328	0.210	0.565	0.622	0.00012	0.558	0.211	0.708	0.452	0.596	0.414	0.458	0.583
-500	-1000	1.115	0.601	0.227	0.406	0.724	0.00009	0.989	0.472	1.463	0.956	0.392	0.743	0.825	0.705
0	-1000	1.994	1.739	0.592	1.150	1.319	0.00007	0.747	0.900	1.247	2.021	0.916	0.821	1.598	0.741
500	-1000	1.250	0.962	0.315	1.224	1.297	0.00007	0.421	1.583	2.170	0.898	0.465	0.572	1.183	1.012
1000	-1000	0.812	0.431	0.358	0.908	1.007	0.00012	0.567	0.623	0.852	0.773	0.206	0.437	0.921	0.341
-1000	-500	0.618	0.777	0.283	1.580	0.439	0.00007	0.906	0.194	0.884	0.605	0.619	0.952	0.777	0.643
-500	-500	2.143	1.083	0.779	1.496	2.033	0.00004	1.914	0.736	2.503	2.775	2.063	1.445	1.594	2.051
0	-500	6.487	5.424	1.462	3.732	4.399	0.00002	2.607	3.104	4.275	6.211	2.961	2.623	2.522	2.602
500	-500	2.793	1.523	1.425	3.165	3.364	0.00004	1.918	2.131	2.817	2.539	0.723	1.512	3.086	1.180
1000	-500	1.116	1.011	0.501	1.719	1.684	0.00009	1.190	1.137	1.236	1.083	0.360	1.335	1.500	0.492
-1000	0	0.599	1.528	0.310	3.155	0.482	0.00003	0.951	0.268	0.586	1.069	0.478	0.598	1.106	0.116
-500	0	1.991	5.025	1.200	10.459	1.690	0.00001	3.390	1.011	1.944	3.772	2.873	2.245	3.767	0.451
500	0	4.109	5.741	3.438	3.509	7.439	0.00002	11.232	6.496	6.431	8.061	6.238	5.077	6.195	4.197
1000	0	1.281	1.712	0.995	1.040	2.485	0.00009	3.470	1.946	2.023	2.523	0.736	1.474	1.929	1.201
-1000	500	0.614	1.183	0.084	1.365	0.421	0.00002	0.385	0.398	0.173	0.967	0.933	0.490	0.875	0.153
-500	500	1.346	1.810	0.445	2.720	1.111	0.00001	0.308	1.211	0.401	2.353	1.801	1.164	2.004	0.697
0	500	4.416	3.463	1.429	2.736	3.677	0.00001	1.790	3.932	5.818	6.191	4.266	6.837	4.006	3.413
500	500	2.016	1.401	0.669	1.586	4.403	0.00004	4.930	1.584	4.428	2.065	2.836	4.201	3.486	1.566
1000	500	1.045	1.104	0.343	0.940	2.075	0.00011	3.243	1.165	1.530	1.577	0.972	2.165	2.035	1.977
-1000	1000	0.400	0.534	0.143	0.642	0.311	0.00003	0.081	0.318	0.249	0.712	0.535	0.342	0.556	0.200
-500	1000	1.016	0.828	0.356	0.534	0.681	0.00003	0.243	0.718	0.436	1.063	0.915	0.784	0.430	0.591
0	1000	1.257	1.015	0.397	0.881	1.107	0.00005	0.522	1.202	1.432	1.913	1.190	2.094	1.239	0.927
500	1000	1.477	0.682	0.204	0.656	1.485	0.00004	1.070	0.628	1.546	0.941	1.492	2.803	1.708	0.866
1000	1000	0.588	0.390	0.170	0.464	1.467	0.00014	1.486	0.451	1.335	0.582	0.412	1.242	0.016	0.427
-24000	-24000	0.004	0.002	0.002	0.002	0.003	0.00017	0.002	0.001	0.002	0.004	0.002	0.002	0.001	0.003
-22000	-24000	0.004	0.002	0.003	0.004	0.005	0.00018	0.004	0.001	0.004	0.007	0.003	0.001	0.003	0.002
-20000	-24000	0.003	0.002	0.003	0.002	0.003	0.00019	0.005	0.001	0.004	0.006	0.005	0.002	0.003	0.003
-18000	-24000	0.004	0.002	0.003	0.003	0.003	0.00019	0.004	0.001	0.006	0.005	0.004	0.001	0.003	0.006
-16000	-24000	0.006	0.003	0.002	0.004	0.004	0.00020	0.005	0.002	0.009	0.006	0.003	0.002	0.005	0.003
-14000	-24000	0.006	0.004	0.002	0.006	0.004	0.00020	0.006	0.002	0.010	0.011	0.002	0.003	0.004	0.003
-12000	-24000	0.006	0.002	0.003	0.003	0.003	0.00020	0.004	0.003	0.008	0.004	0.002	0.001	0.002	0.003

APPENDIX G

Spatial Analysis System

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G.1 INTRODUCTION

A vital tool in the analysis of the public benefits of proposed revisions to Regulation 308 used was DPA's spatial analysis system (SPANS). SPANS is a geographic information system. Different geographic information systems specialise in performing different tasks; some work best at creating cartographic maps. SPANS' specialty is analysis and manipulation of spatial data; data which relate to points or areas on maps. It was ideally suited to this assignment which involved locating sources of emissions, the dispersion of those emissions, and identification of the population and environmental resources affected.

This appendix describes some of the features of SPANS and the way it was used in the project.

G.2 WHAT IS SPATIAL ANALYSIS?

Spatial analysis is the ability to investigate the spatial dimension of a problem. Many problems have a spatial dimension. For instance, the analysis of the public benefits of reduced air emissions depend upon where contaminants are deposited and the concentration at each point because that determines the resources affected. Traditionally, the spatial dimensions of problems are addressed by making assumptions (e.g., trade area boundaries) or using manual procedures (map overlays) that limit the number of options considered.

DPA's computerized spatial analysis system allows the spatial components of a problem to be addressed in much more sophisticated and convenient ways. To understand how the spatial analysis system works some background information on geographic information systems is useful.

G.3 GEOGRAPHIC INFORMATION SYSTEMS

Computerized geographic information systems (GIS) are designed to input, store, retrieve, manipulate and display spatial information. They differ primarily in the manner in which they store data and the kind of manipulations they perform best. In turn these capabilities determine the size of computer needed.

G.3.1 Data Storage

A spatial feature has a location, size and shape. The size and shape can range from a point (e.g., a meteorological station) to an irregular area (e.g., a watershed). In addition to these spatial characteristics, the GIS must store a range of attributes associated with the site: average annual temperature, soil type, slope, population, suitability for swimming, etc. Clearly, the data storage demands can quickly become very large, creating a need for larger computers.

The most common approach to accurately specify spatial features is to define their boundaries. A series of line segments are linked to form the boundary of an area. Obviously, the more irregular the area the larger the storage requirements. Some analytical processes, such as map overlays, are very complex with these systems. Line segments must be used to generate the areas, the areas are overlaid, the portions that overlap are determined and a new set of boundary line segments is generated for storage. These systems typically require mini-computers.

The usual approach to minimising storage needs is to pre-define a fixed set of areas. Typically this is a grid (raster) system, although other systems, such as census subdivisions, can be used.

The fixed areas and locations defined by such systems yield major benefits in terms of data storage. The cost is loss of accuracy. Watersheds, slopes, soils, rainfall and many other attributes do not vary according to a fixed grid pattern.

SPANS uses a quadtree structure to store data. This offers a combination of the best features of a boundary-based system and grid system. The quadtree structure divides the total area into progressively smaller quadrants, until a quadrant has uniform characteristics. This results in area units of variable size, so a large area with uniform attributes is stored as such, while much smaller area units are used to accurately define the boundaries of spatial features, such as forest cover, lakes, and built up area. The overall data storage requirements are similar to those for a fixed area system, but the level of accuracy is much greater. The system operates on a micro computer.

G.3.2 Manipulation Capabilities

The manipulation capabilities of a GIS system reflect the needs of users and, to some extent, the data storage techniques employed. The available systems can be broadly defined as cartographic or thematic in orientation. The principal uses of cartographic systems are to record, process revisions to, and prepare updated maps. Although these systems have some analytical capabilities, such as the ability to perform overlays, the emphasis is on cartographic properties such as accuracy, labelling, changes to scale and projection, etc.

Conversely thematic systems emphasize analytical capabilities but at the cost of some cartographic ability such as labelling. SPANS was specifically designed as an analytical system. Its capabilities include:

- . Easy access to a variety of input data;
- . Extensive data manipulation capabilities;
- . Complex overlays of multiple maps;
- . Proximity mapping;
- . Area analysis reports;
- . Use of satellite imagery; and
- . Diverse data display capabilities.

SPANS grew out of needs encountered in the course of DPA's consulting work over the past decade. The system was developed, refined and enhanced over many years and a wide variety of applications.

G.4 USE OF SPANS IN THIS PROJECT

A critical requirement in the calculation of the public benefits of reduced air emissions is the ability to estimate the change in concentration of a given contaminant at any point and to determine the environmental resources that will benefit from this reduced exposure. SPANS provides this capability.

G.4.1 Location of Emission Sources

SPANS is used to locate each emission source. The list of establishments was compiled from the Made in Ontario data base maintained by the Ministry of Industry, Trade and Technology and Statistics Canada's list of establishments. The Made in Ontario data base includes the postal code and these establishments were located at the (six digit) postal code centroid. The centroid locations for postal codes were purchased from Statistics Canada. The Statistics Canada list only gives the municipality. These establishments were located at the centroid for the

municipal unit. The municipality centroid was calculated using SPANS.

To facilitate the calculation of depositions from different sources, a standard 4 km grid was created. Each establishment was moved to the nearest grid point, a distance of less than 2 km. Given that the initial location was the postal code or municipality centroid, this did not introduce a significant bias or error into the analysis. Grid points with numerous (over 10) establishments were examined. The larger firms assigned to that grid point were contacted and, if appropriate, shifted to other grid points. However, it remains true that establishments are artificially concentrated on some grid points due to the lack of accuracy of the address information. The establishments from the Statistics Canada list are concentrated at fewer locations because there are fewer municipalities than postal codes.

The attributes stored for each establishment are its:

- . Canadian SIC code;
- . estimated employment (or other size characteristic);
- . estimated current emissions by contaminant;
- . estimated emissions by contaminant for each implementation scenario; and
- . an indicator to identify the appropriate dispersion pattern.

G.4.2 Determination of Concentrations

The dispersion modelling (see Appendix F) calculated 14 dispersion patterns for different parts of the province. The dispersion model assumed an emission rate of 1 gm/sec and calculated the resulting concentration (micrograms/cu.m) on a 2 km grid covering an area 24 km in all directions from the source.

To keep the calculations manageable -- 65 contaminants, over 3,500 establishments, 5 scenarios -- it was necessary to adopt a coarser grid. Thus, a 4 km grid rather than a 2 km grid was used. Since the sources had been moved to points on a 4 km grid, the concentration estimates also corresponded to points on this grid.

The analysis proceeds on a contaminant by contaminant basis. If an establishment is a source of the contaminant, the emissions for the specified scenario are converted to an emission rate. The appropriate dispersion pattern is selected. The origin of the dispersion pattern is adjusted to the source location. Every point in the dispersion grid is similarly adjusted to points on the province-wide grid. The concentration at each point on the dispersion grid is scaled by the emission rate and added to the existing concentration at that point on the province-wide grid.

When this process has been completed the grid points reflect the estimated concentration of the contaminant at that point due to emissions from all establishments under the given scenario. The concentration at each grid point is assumed to apply to a 4 km square area with the grid point at its centre.

G.4.3 Calculation of Ambient Concentration

The dispersion model estimates the concentration of a contaminant due to a specific source. Many of the contaminants analysed are also emitted by sources other than those considered in this study. Thus, the ambient concentration due to all sources is likely to be higher than the estimated emissions from the Regulation 308 sources covered by this study.

Data on total ambient concentrations are collected by monitoring stations. Two networks of monitoring stations exist in Ontario. One network has stations located in areas where air quality

problems are believed to exist. The other network has stations located more uniformly across the province to collect data to monitor acidic deposition. Each monitoring station collects information on ambient concentrations of a number of contaminants. Of the 96 contaminants, monitoring data are available for cadmium, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide, total particulate matter (PM) and total VOC's.

For each of these contaminants except total VOC's, the ambient concentration as recorded by the monitoring station was compared with the concentration at the monitoring station location estimated using the dispersion model. The result is a series of "residuals" (one for each monitoring station) that represent the ambient concentration due to non-Regulation 308 sources. These residuals were examined individually for each contaminant. Based on this examination, one (or more) values of the ambient concentration due to non-Regulation 308 sources were established. The value(s) and the rationale for the selection is presented in Chapter 4 in the section relating to the specific monitored contaminant.

The value(s) of the concentration due to non-Regulation 308 sources is added to the estimated concentration due to Regulation 308 sources at each grid point for all scenarios. This converts the value at each grid point from an estimate of the concentration due to the specific Regulation 308 sources analysed to an estimate of total ambient concentration. And it permits an analysis of the impact of the proposed changes to Regulation 308 on total ambient concentration of the given contaminant. The ambient concentration at each grid point is assumed to apply to a 4 km square area with the grid point at its centre.

This procedure is only possible for the nine contaminants -- cadmium, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide and PM -- for which monitoring data are available. The procedure was not used with VOC's because the monitoring stations report total VOC's and we did not have a reasonable basis for speciating this total at each monitoring station.

G.4.4 Maps of Environmental Resources at Risk

Having determined the geographic dispersion of a contaminant and its concentration at each point, it is necessary to relate that information to the resources at risk. These include humans, crops, livestock, forests and surface water. Maps of these resources were purchased from various sources and converted to SPANS format.

Population by enumeration area for the 1986 census was purchased from Statistics Canada. The enumeration area population totals were aggregated to the census subdivision level. The area of each census subdivision was calculated by SPANS. This allowed the population figure to be converted to a population density (people per sq. km). The population density is assumed to be uniform across the census subdivision.

Agricultural data from the 1986 Census of Agriculture were purchased from Statistics Canada. The information is available at the consolidated census sub-division level. Only the total crop acreage by consolidated census sub-division was mapped.

Forestry data were obtained from the National Forestry Service in Petawawa. A map of surface water for Ontario was purchased from the Canada Lands Directorate Service.

G.4.5 Analysis of Environmental Resources at Risk

For most contaminants, only the estimated emissions due to Regulation 308 sources are available. In these cases where the analysis can only identify the environmental resources at risk. The dispersion pattern for the contaminant is superimposed on the appropriate environmental resource(s), usually population. This is done for each scenario. The difference between the current resource exposure and the exposure under each scenario is calculated. This indicates the maximum change in environmental resources at risk by scenario.

In each of these cases, the estimated emissions due to Regulation 308 sources are also compared to the threshold values above which observable effects occur. In virtually every instance the current emissions are well below the threshold level.

G.4.6 Analysis of Contaminants for which Ambient Concentrations have been Estimated

The nine contaminants -- nickel, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide and PM -- for which total ambient concentrations are estimated are analysed in a manner similar to that outlined above.

The areas where the total ambient concentration exceeds the threshold value for observable effects is plotted for the existing situation and for each scenario for implementation of proposed changes to Regulation 308. The difference in the resources (population, crops, forests) exposed to above-threshold levels of the contaminant is a measure of the public benefits of the proposed revisions to Regulation 308.

G.4.7 Analysis of Cases with Exposure-Response and Damage Functions

In the case of cancer, and systemic health, visibility and soiling effects in the case of a few important contaminants, exposure-response and damage functions are available. These functions calculate the benefits of reduced exposure from the change in exposure and the population exposed.

For each scenario, the reduction in exposure from the existing level is calculated at each grid point. This change is multiplied by the population density in the 4 km square of which the grid point is the centre and by the area (16 km²) to get the population and change in exposure. These values are summed over all relevant grid points and the aggregate values are used in the exposure-response and damage function to calculate the estimated benefits of reduced emissions.

Maps showing the dispersion patterns by contaminant are provided in Appendix I.

APPENDIX H

Exposure Response Functions

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H.1 INTRODUCTION

An exposure-response function predicts how health and other factors, such as visibility and materials damage, change as the concentration of a contaminant changes. Exposure-response functions are the most commonly available for deaths by cancer. Functions are also available for other health effects from nitrogen dioxide, sulphur dioxide, and suspended particulate matter.

The exposure-response functions are discussed below for cancer and various effects of nitrogen dioxide, sulphur dioxide, and suspended particulate matter. The functions used are listed under the contaminant in question in Appendix C. They are elaborated here for greater clarity. For many non-cancer effects, upper, lower, and central values for the function are listed in Appendix C. We have calculated the lower and central value for each function.

H.2 CANCER FUNCTIONS

The change in cancer deaths due to a change in the concentration of a contaminant is predicted using a unit risk factor. The unit risk factors we used are usually IRIS (Integrated Risk Information System) values. Where IRIS values are not available, we used Massachusetts unit risk factors.

The change in annual cancer mortality from a change in the concentration of a chemical is calculated using the following formula:

$$ACM = URF \times CONC \times POP / 70$$

Where:

- ACM = Change in annual cancer mortality resulting from the change in concentration of the contaminant.
- URF = The IRIS (or Massachusetts) Unit Risk Factor.
- CONC = Change in concentration of the contaminant measured on an annual basis expressed in micrograms per cubic metre.
- POP = The population subject to the change in contaminant concentration.
- 70 = A factor converting lifetime (estimated to be 70 years) deaths to annual deaths.

The change in annual cancer mortality (ACM) is calculated for each contaminant for which a cancer unit risk factor is available. The calculation is performed for each of the implementation scenarios.

The calculation is performed as follows for a given contaminant and scenario. Each of the over 15,000 grid cells used in the analysis has a change in contaminant concentration specific to the contaminant and scenario (current concentration in micrograms per cubic meter as an annual average less projected concentration under the specified scenario in micrograms per cubic metre as an annual average). The change in contaminant concentration (CONC) for a grid cell is multiplied by the population (POP) of the grid cell. The products of these multiplications are summed over all grid cells. The sum is then multiplied by the cancer unit risk factor (URF) and divided by 70 to yield the change in annual cancer mortality.

Using arsenic as an example, the change in concentration multiplied by the population summed over all grid cells is as follows by scenario:

	Change in Concentration x Population	Unit Risk Factor	Change in Annual Cancer Mortality*
Scenarios "A" & "D"	117,335	4.3×10^{-3}	7.2
Scenario "B"	128,240	4.3×10^{-3}	7.9
Scenario "C"	105,577	4.3×10^{-3}	6.5
Scenario "E"	113,821	4.3×10^{-3}	7.0

* $117,335 \times 0.0043/70 = 7.2$

The unit risk factor for each carcinogen for which information is available is shown in Exhibit H.1.

H.3 NITROGEN DIOXIDE FUNCTIONS

Exposure-response functions for nitrogen dioxide have been developed for:

- . eye irritation;
- . visibility effects; and
- . materials damage.

The functions listed below are derived from the material presented in Appendix C.

H.3.1 Eye Irritation

The eye irritation damage function depends upon measurement of average daily high concentration of NO_2 . We only had information on annual average concentration and therefore were unable to calculate changes eye irritation under the proposed implementation scenarios due to reduced emissions of NO_2 .

EXHIBIT H.1: : CANCER UNIT RISK FACTORS

<u>Contaminant</u>	<u>Unit Risk Factor</u>
Acrylonitrile	6.8×10^{-5}
Arsenic	4.3×10^{-3}
Asbestos	7.6×10^{-3}
Benzene	8.3×10^{-6}
1,3 Butadiene	2.8×10^{-4}
Cadmium	1.8×10^{-4}
Carbon Tetrachloride	1.5×10^{-5}
Chloroform	2.3×10^{-5}
Chromium	1.2×10^{-2}
Epichlorohydrin	1.2×10^{-6}
Ethylene Dichloride	2.6×10^{-5}
Formaldehyde	1.3×10^{-5}
Methylene Chloride	4.1×10^{-6}
Nickel	4.8×10^{-4}
Polychlorinated Biphenols	2.2×10^{-3}
Propylene Oxide	6.67×10^{-7}
Styrene	5.7×10^{-7}
Toluene Diisocyanate	6.79×10^{-6}
1,1,1-Trichloroethane (Methyl Chloroform)	1.6×10^{-5}
Trichloroethylene	1.3×10^{-6}
Vinyl Chloride	2.6×10^{-6}

Source: Appendix C

H.3.2 Visibility Effects

We adjusted the function given in Appendix C as follows:

$$\begin{array}{lcl} \text{Total} & & \\ \text{Value} & = & E \times 205 \times \ln [1/(1-(0.035 \times (NO_{2A} - NO_{2B}) \times \\ \text{Per Year} & & 100/NO_{2A}))] \times \text{POP}/\text{HF} \end{array}$$

Where:

- E = The mean 1986 rate of exchange (1.3894) to convert 1986 U.S. to 1986 Canadian dollars.
- ln = The natural logarithm.
- 0.035 = A mean value for the function, which varies according to urban or rural location. (Taking a mean value biases the result, but the difference between urban and rural location is not as great as the upper and lower bounds for this function.)
- NO_{2A} = The current NO₂ concentration for the grid cell.
- NO_{2B} = The NO₂ concentration for the same grid cell under the specified implementation scenario.
- POP = The population of the grid cell.
- HF = A factor (2.8) to convert population to the number of households.

The function given above is the central case estimate. To get the lower bound estimate, the constant 205 is replaced by 100. In other words, the lower bound is equal to the central case divided by 2.05.

As was the case for the cancer mortality equation, the calculation is performed for each of the over 15,000 grid cells

and then summed. Specifically,

$$\ln [1/(1-(0.035 \times (\text{NO}_{2A} - \text{NO}_{2B}) \times 100/\text{NO}_{2A}))] \times \text{POP}/\text{HF}$$

is calculated for each grid cell. These values are then summed over all grid cells. And the sum is multiplied by $E \times 205$ to get the final result.

Note that the output is a dollar value; there is no physical value such as "number of days of poor visibility", analogous to the number of deaths, hospital days, etc. in the other functions.

H.3.3 Materials Damage

The materials damage function for nitrogen dioxide is expressed in similar terms. The equation describes the annual materials damage value per person. For the central case, the materials damage equation is:

$$\begin{array}{l} \text{Total} \\ \text{Value} \\ \text{Per Year} \end{array} = E \times 1.51 \times [(\text{NO}_{2A} - \text{NO}_{2B}) \times 100/\text{NO}_{2A}] \times \text{POP}$$

The symbols have the same meaning as in the visibility equation. Thus, materials damage is a function of the percentage change in nitrogen dioxide concentration and population.

The function shown above is the central case. The lower bound is calculated as 0.5 times the central case.

H.4 SULPHUR DIOXIDE FUNCTIONS

H.4.1 Mortality

An exposure-response function is available for deaths attributable to sulphur dioxide. The function in Appendix C is adjusted as follows to calculate absolute change in the number of annual deaths.

$$\text{Deaths} = 2.672 \times 10^{-5} \times \text{POP} \times (\text{SO}_{2A} - \text{SO}_{2B})$$

Where:

- SO_{2A} = The SO₂ concentration for a grid cell under existing regulations.
- SO_{2B} = The SO₂ concentration for a grid cell under a specific implementation scenario.
- POP = The population of a grid cell.

The function presented above is the central case estimate for reduction in annual mortality due to reduced concentrations of sulphur dioxide. The low case is calculated by applying the lower bound estimate of the value of a statistical life to the calculated reduction in mortality.

H.4.2 Hospital Days for Respiratory Conditions

The function of hospital days for respiratory conditions (HDRC) is:

$$\text{HDRC} = 4.0 \times 10^{-4} \times (\text{SO}_{2A} - \text{SO}_{2B}) \times \text{POP}$$

The variables SO_{2A}, SO_{2B} and POP have the same meaning as in the mortality equation.

The lower bound estimate is obtained by replacing 4.0×10^{-4} in the central case equation presented above with 1.5×10^{-4} . In other words the lower bound is 0.375 times the central case.

H.4.3 Hospital Admissions for Respiratory Disease

The function for hospital admissions for respiratory disease (HARD) is:

$$\text{HARD} = 4.065 \times 10^{-5} \times (\text{SO}_{2\text{A}} - \text{SO}_{2\text{B}}) \times \text{POP}$$

The variables $\text{SO}_{2\text{A}}$, $\text{SO}_{2\text{B}}$ and POP have the same meaning as in the mortality equation.

The lower bound estimate is calculated by replacing 4.065×10^{-5} in the central case equation presented above with 0.63×10^{-5} . Alternately, the lower bound is 0.155 times the central case.

H.5 PARTICULATE MATTER FUNCTIONS

Six exposure response functions exist for PM. They relate to:

- . death;
- . emergency room visits;
- . restricted activity days;
- . chronic obstructive pulmonary disease;
- . visibility; and
- . materials damage.

The functions below are derived from those in Appendix C. In each case:

- PM_A = The original PM concentration for a grid cell.
 PM_B = The PM concentration for a grid cell under the scenario considered.
 E = The mean 1986 rate of exchange (1.3894) to convert 1986 U.S. to 1986 Canadian dollars.
 HF = A factor (2.8) to convert the population of a grid cell to the number of households.
 POP = The population of a grid cell.

H.5.1 Death

$$\text{Deaths} = 2.21 \times 10^{-6} \times POP \times (PM_A - PM_B)$$

This equation gives the change in annual deaths due to a change in particulate matter concentration. The lower bound and central value are calculated by applying the corresponding values of a statistical life to the reduction in annual mortality estimated using the above equation.

H.5.2 Emergency Room Visits

$$ERV = 1.3 \times 10^{-4} \times POP \times (PM_A - PM_B)$$

The change in the number of emergency room visits per year, ERV, is related to the change in particulate matter concentration. The lower bound estimate of emergency room visits is calculated by replacing the central case coefficient of 1.3×10^{-4} by 1.2×10^{-5} .

H.5.3 Restricted Activity Days

$$\text{RAD} = 2.736 \times 10^{-2} \times \text{POP} \times (\text{PM}_A - \text{PM}_B) - \text{Emergency Room Visits}$$

The change in the number of restricted activity days, RAD, is reduced by the change in the number of emergency room visits (ERV) to avoid double counting. The lower bound estimate of restricted activity days is calculated by replacing the central case coefficient of 2.736×10^{-2} by 1.938×10^{-2} . In other words, the lower bound is equal to 0.70833 times the central case.

H.5.4 Chronic Obstructive Pulmonary Disease

The function in Appendix C deals with changes in risk of pulmonary disease in adults and children. It does not predict actual change in, or values relating to, pulmonary disease. It was therefore impractical to use it in the analysis.

H.5.5 Visibility Effects

$$\begin{array}{l} \text{Total} \\ \text{Value} \\ \text{Per Year} \end{array} = E \times 206 \times \ln (\text{PM}_A / \text{PM}_B) \times \text{POP} / \text{HF}$$

The lower bound estimate is calculated as 0.5 times the central case.

As with visibility effects from nitrogen dioxide, this function returns an annual dollar value for improved visibility.

H.5.6 Materials Damage

$$\begin{array}{l} \text{Total} \\ \text{Value} \\ \text{Per Year} \end{array} = E \times 7.4 \times (\text{PM}_A - \text{PM}_B) \times \text{POP} / \text{HF}$$

This function also returns an annual dollar value of reduced materials damage.

To get the lower bound estimate, the central case coefficient of 7.4 is replaced by 0.52. In other words, the lower bound is 0.07027 times the central case.

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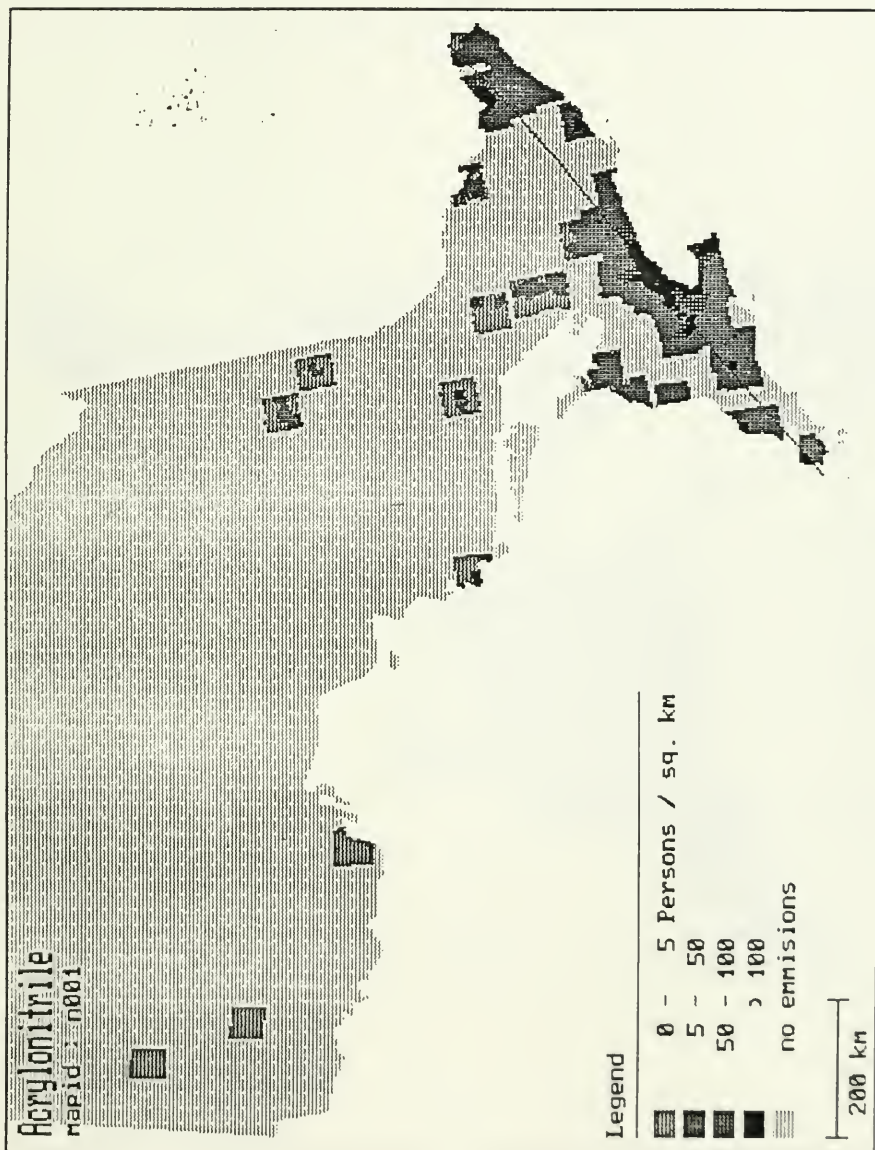
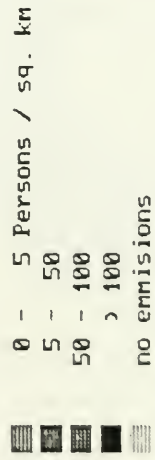


EXHIBIT I.2: LOCATION OF THE LINE ALONG WHICH THE CONCENTRATION PROFILE IS CALCULATED

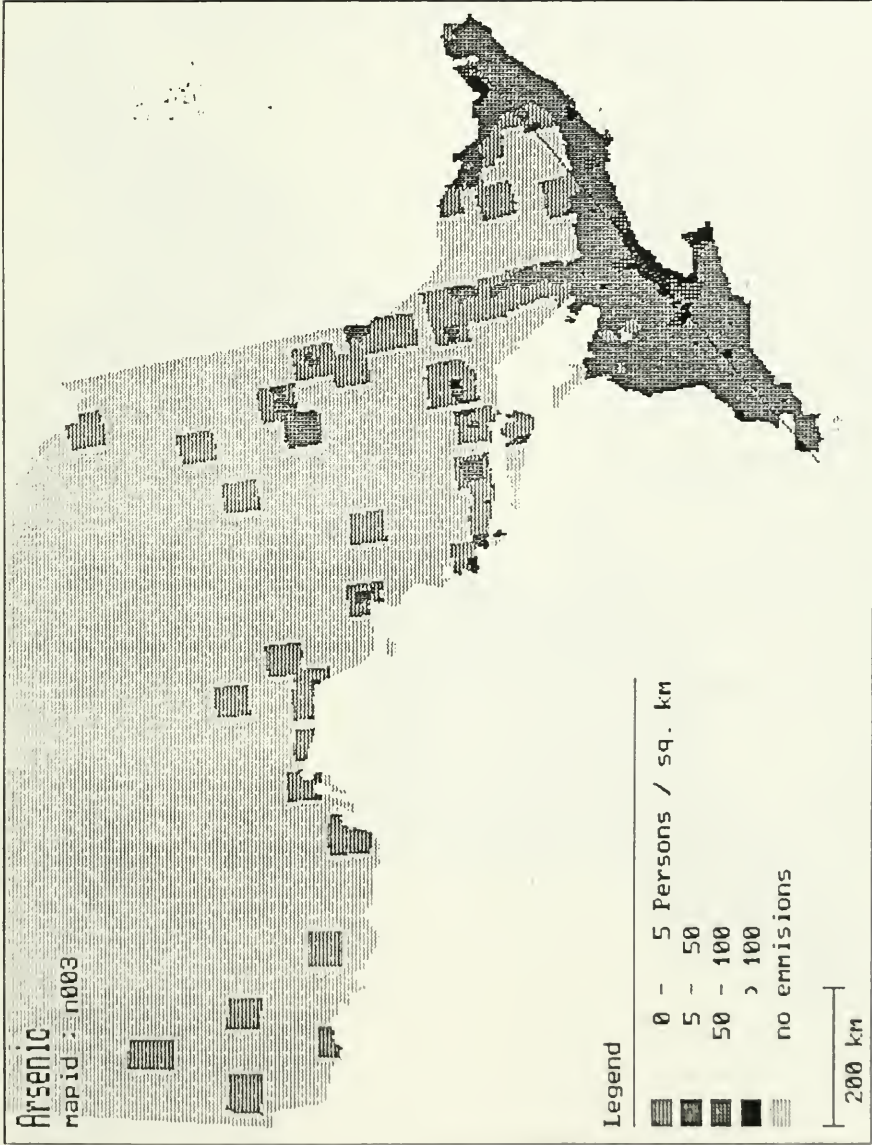


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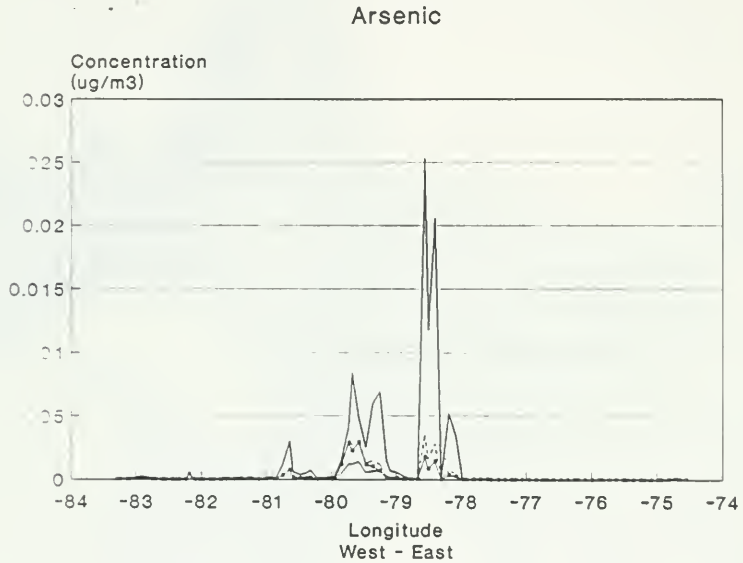
Legend



200 km



AT I.4: PROFILE OF ARSENIC CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



- Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C
Scenario E	+++++

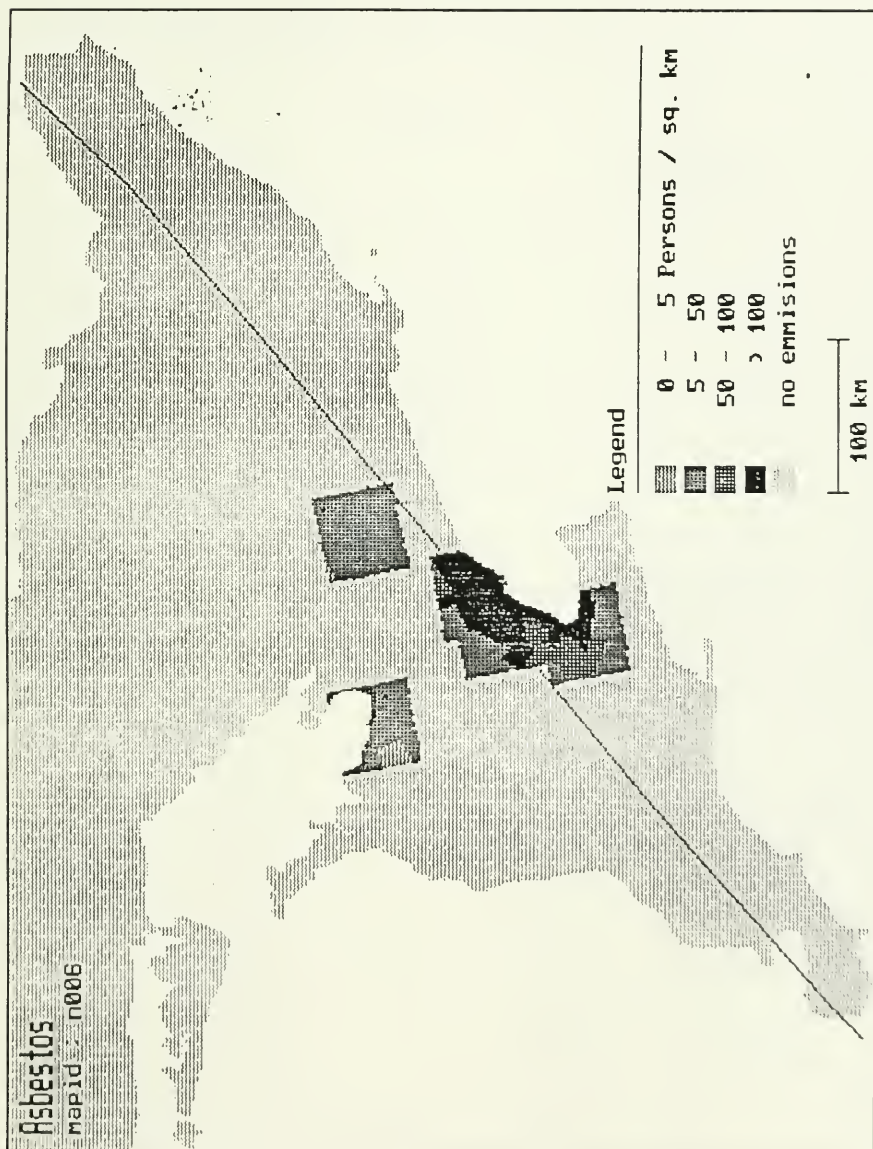
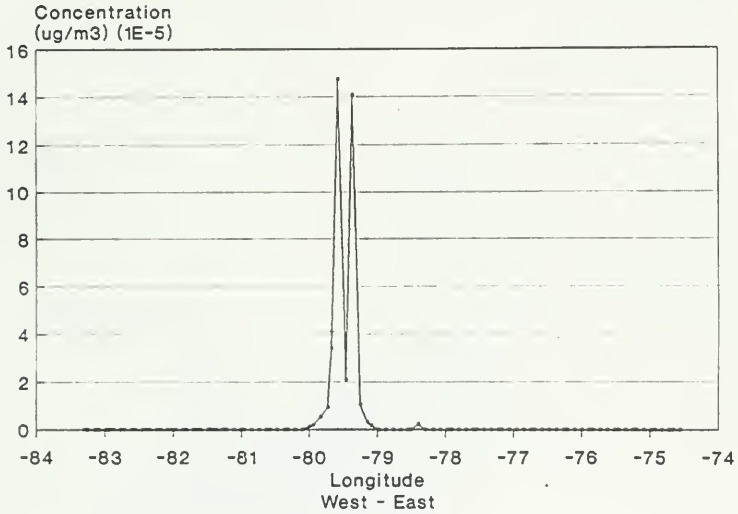


EXHIBIT I.6: PROFILE OF ASBESTOS CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Asbestos



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	+++++

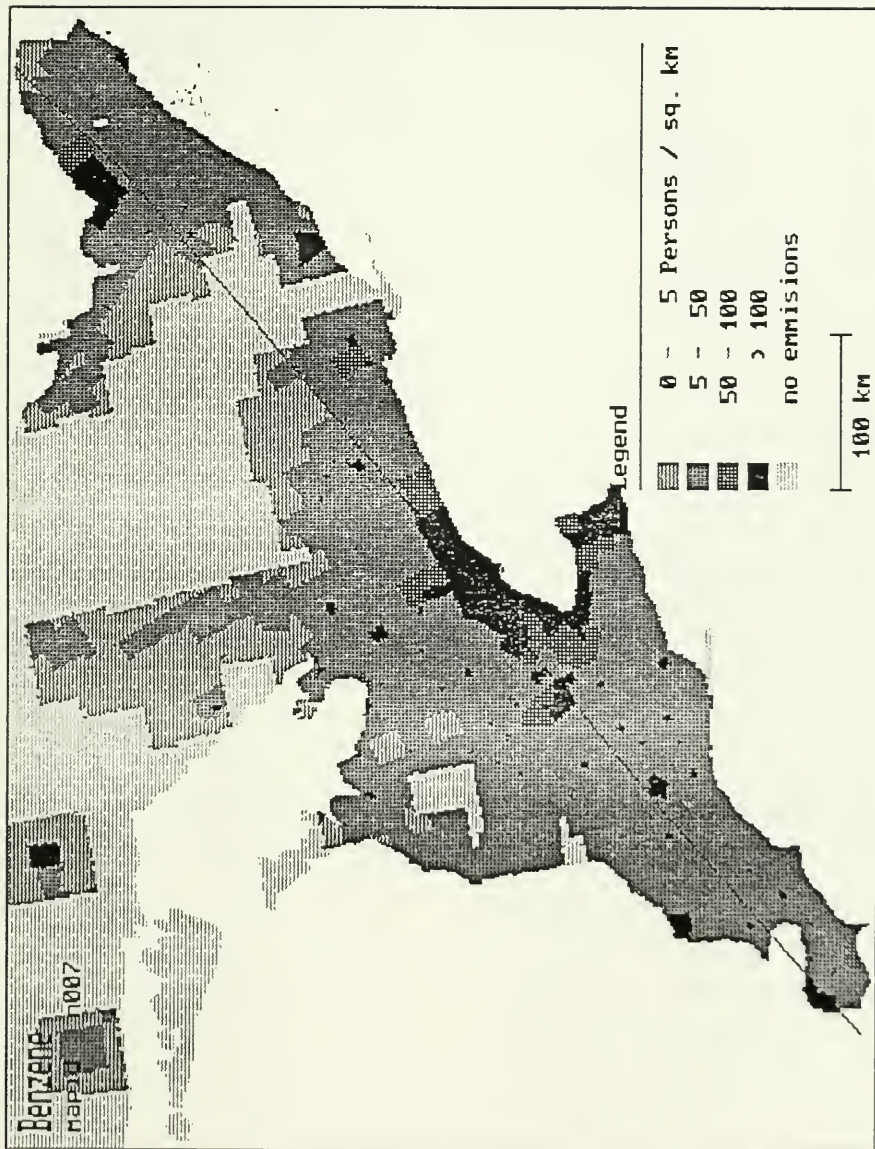
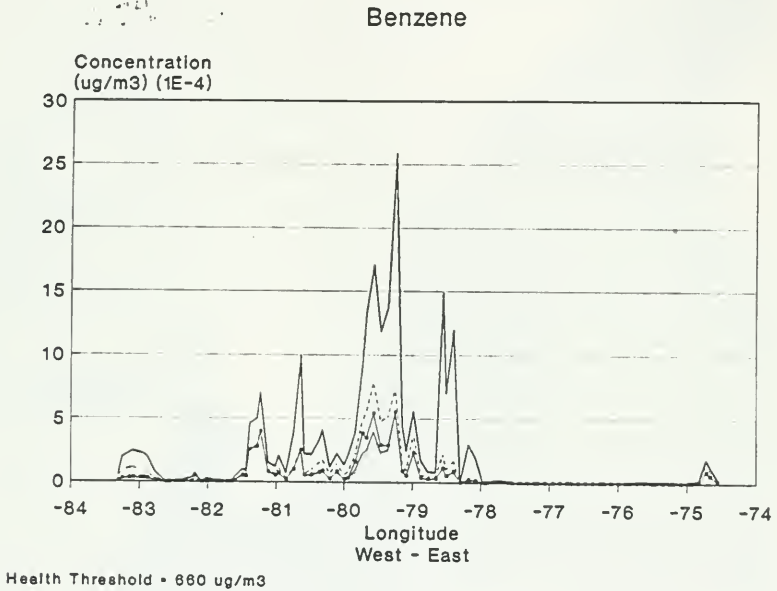


EXHIBIT I.8: PROFILE OF BENZENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

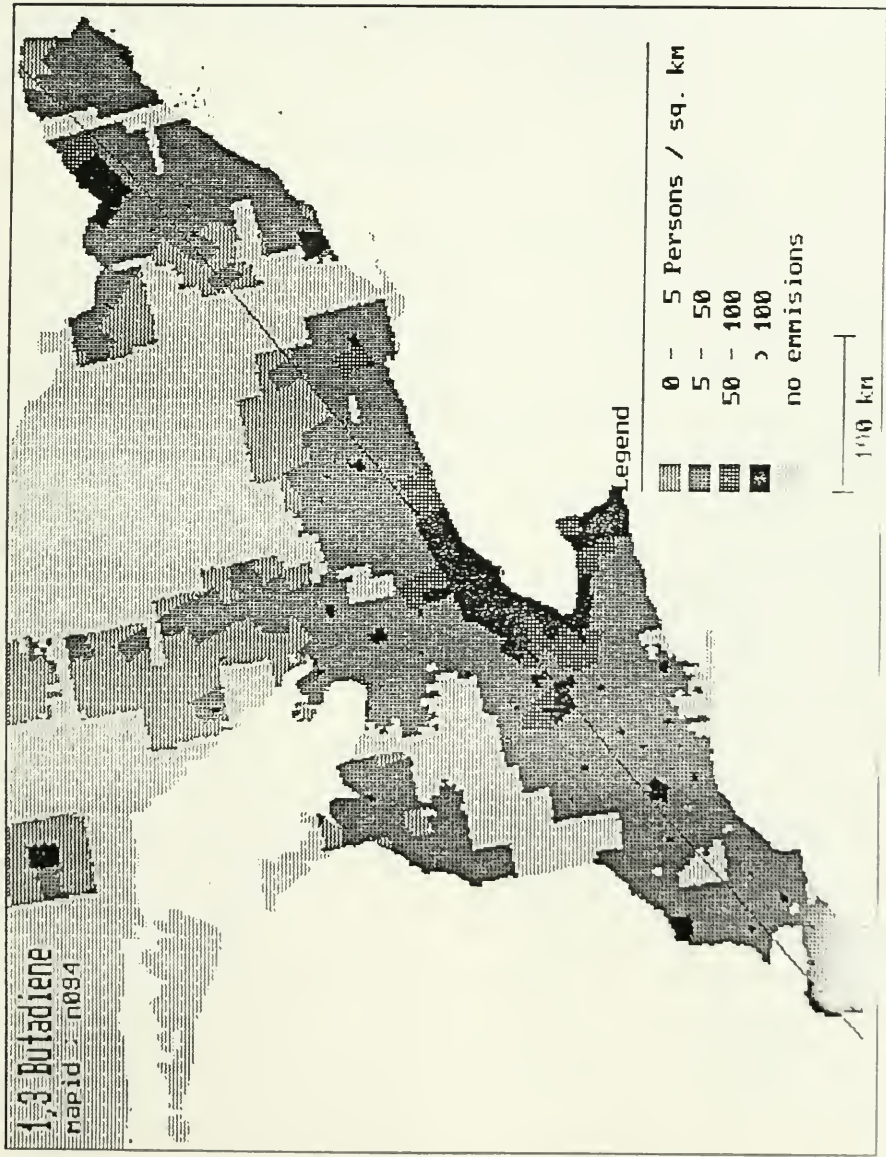
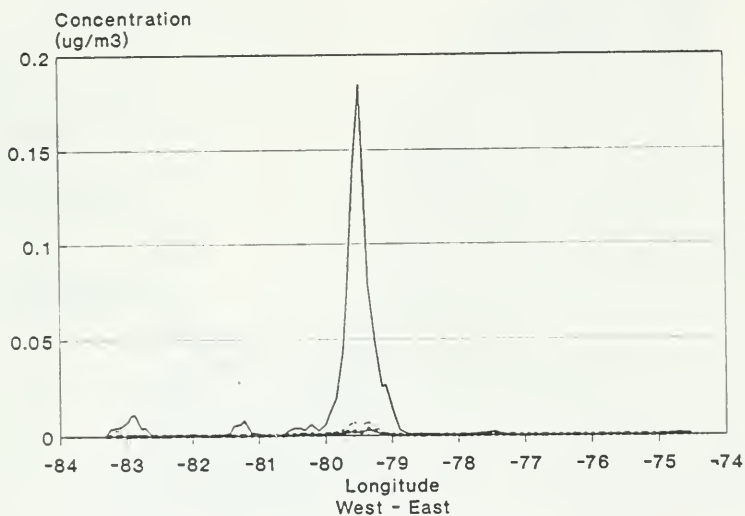


EXHIBIT I.10: PROFILE OF 1,3 BUTADIENE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

1,3 Butadiene



Health Threshold = 22.0 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

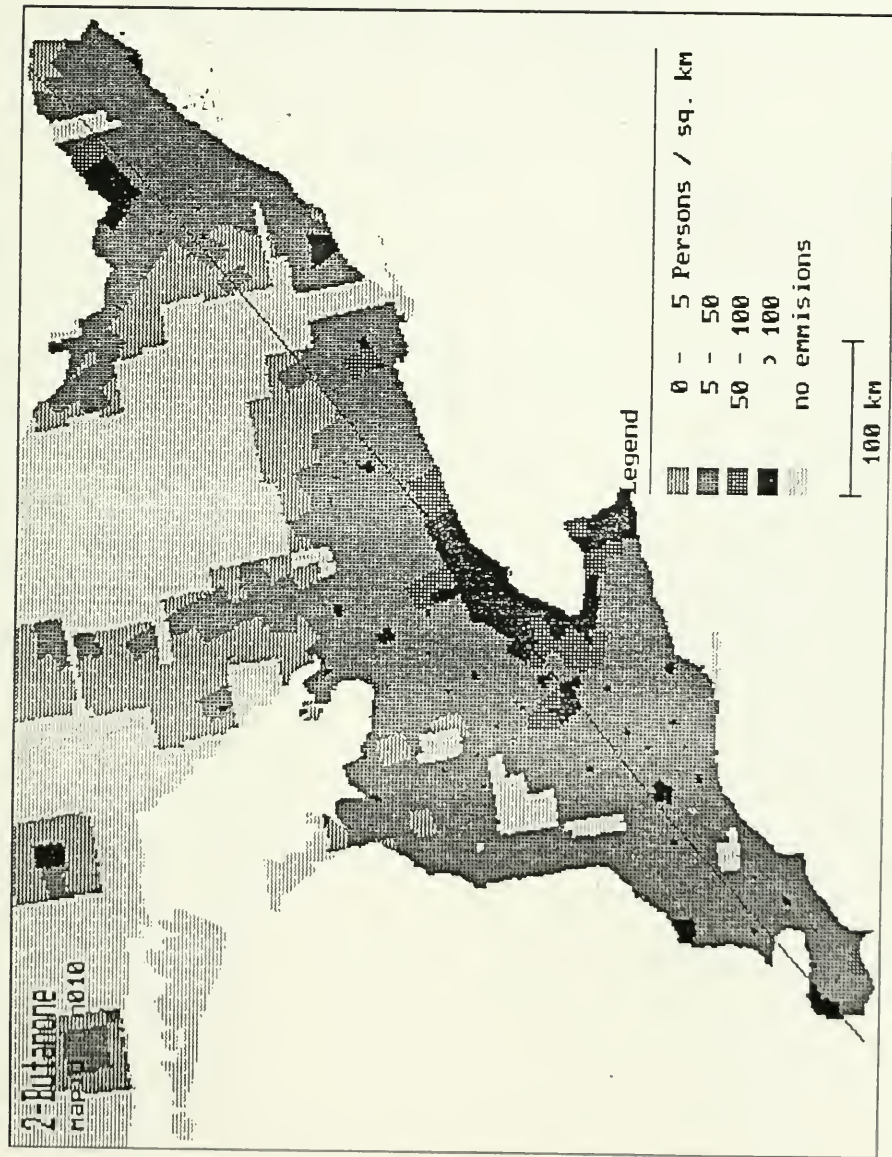
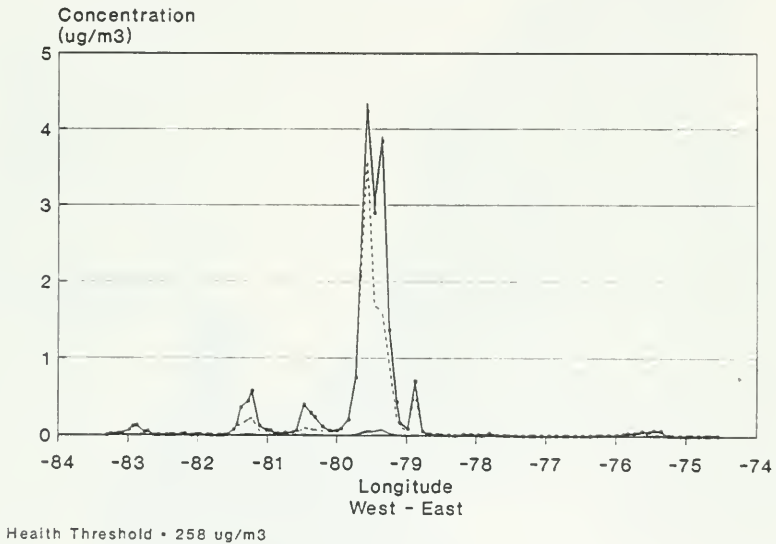


EXHIBIT I.12: PROFILE OF 2-BUTANONE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

2-Butanone



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

EXHIBIT I.13: AREAS EXPOSED TO BUTYL ACRYLATE FROM REGULATION 308 SOURCE EMISSIONS

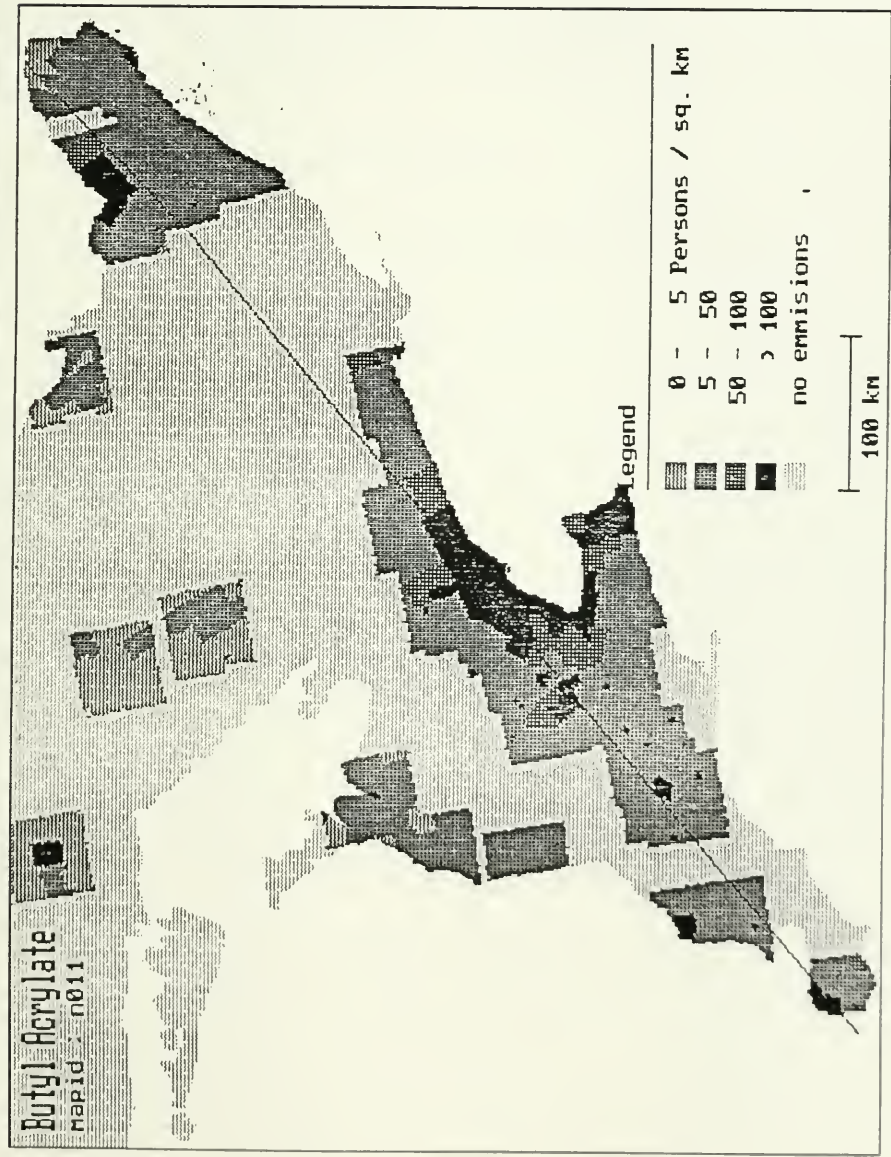
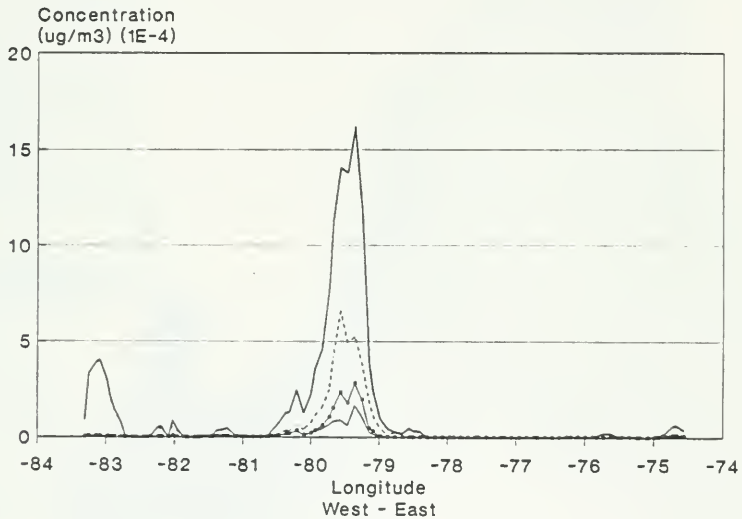


EXHIBIT I.14: PROFILE OF BUTYL ACRYLATE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Butyl Acrylate



Health Threshold = 7.0 ug/m3

Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C	-----
Scenario E

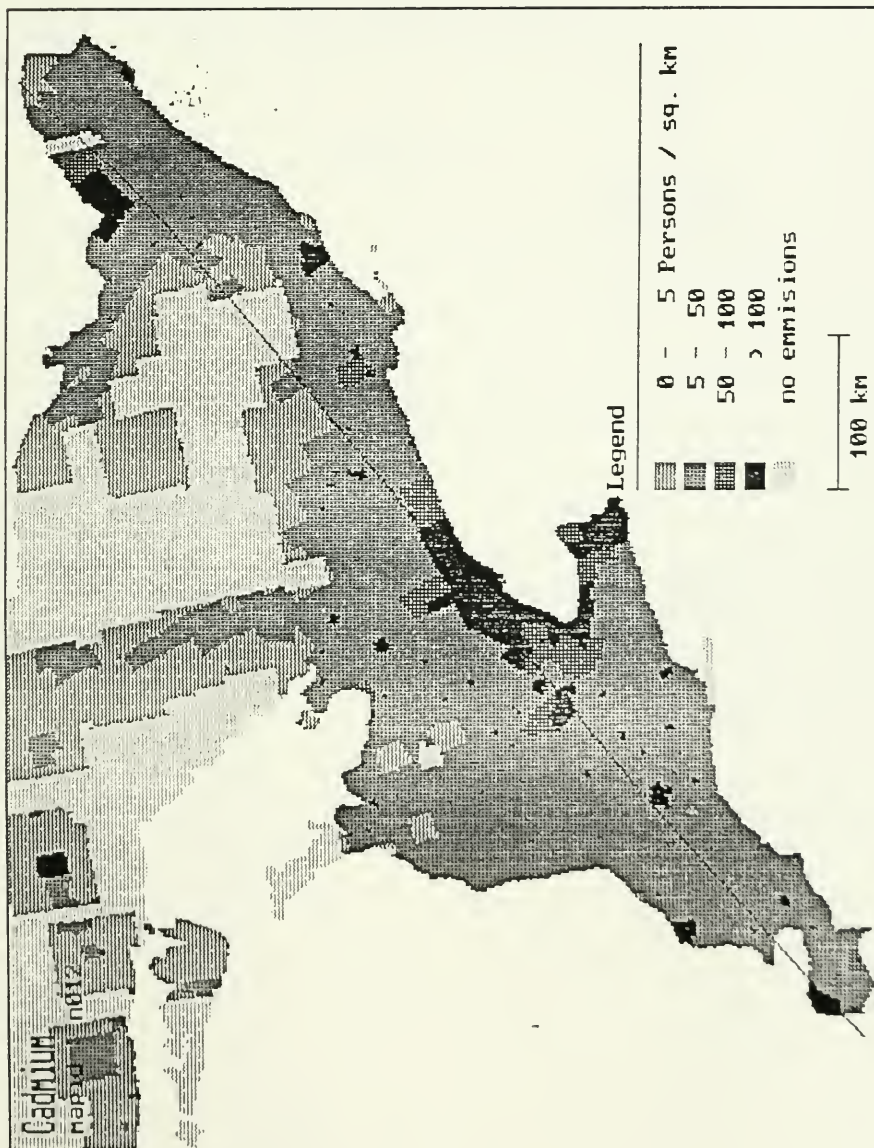
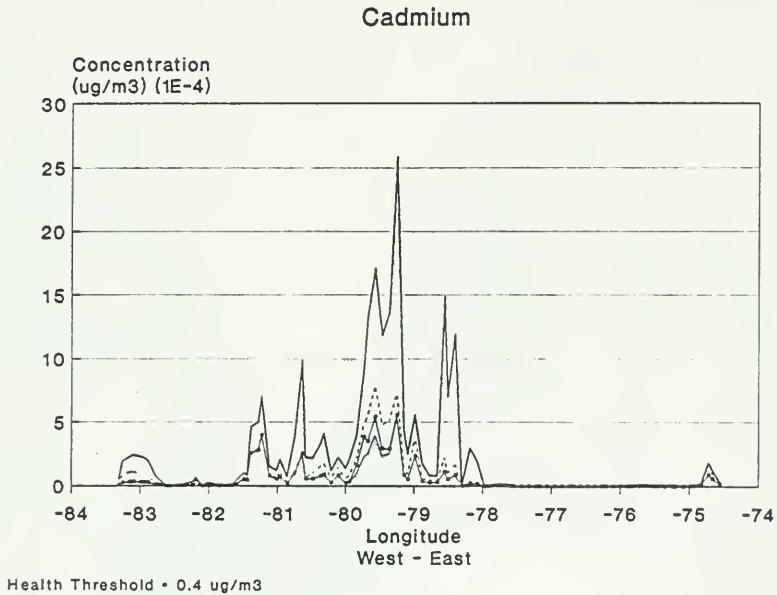


EXHIBIT I.16: PROFILE OF CADMIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

EXHIBIT I.17: AREAS EXPOSED TO CARBON TETRACHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 17

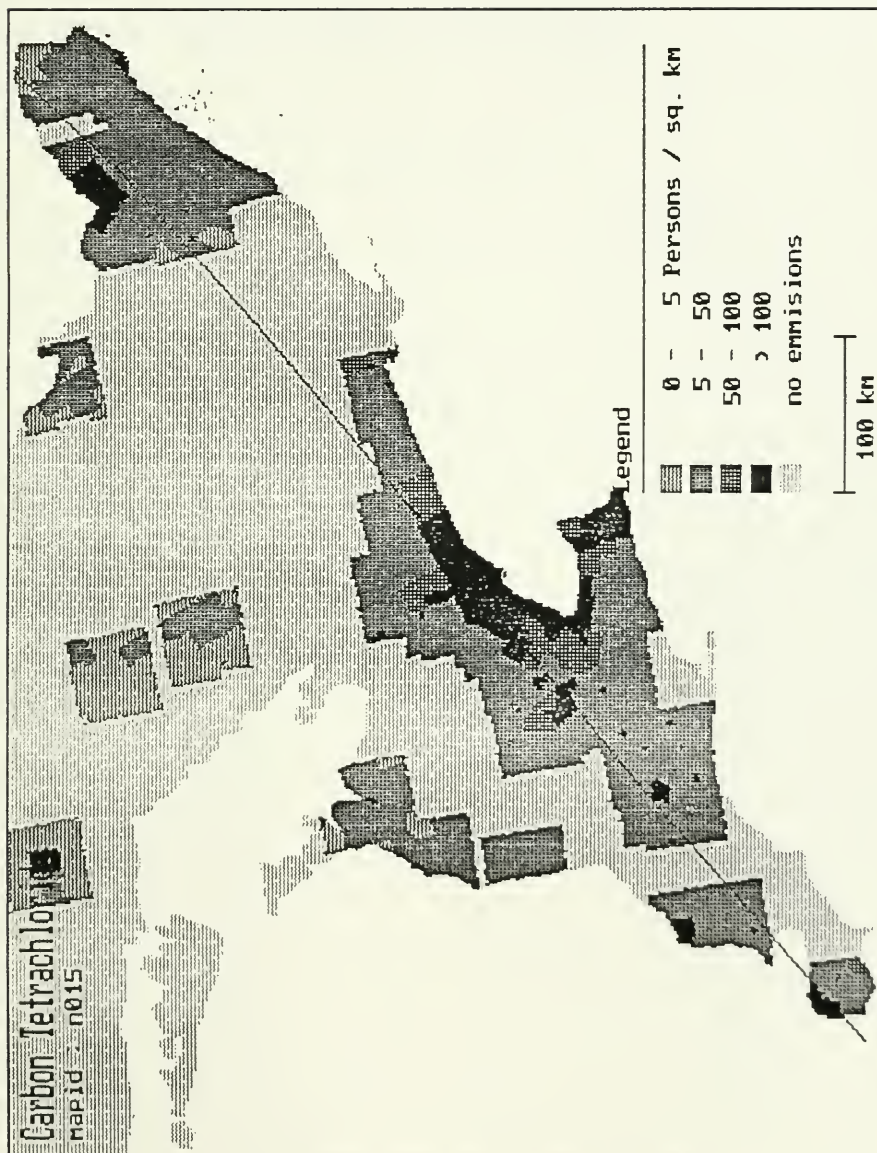
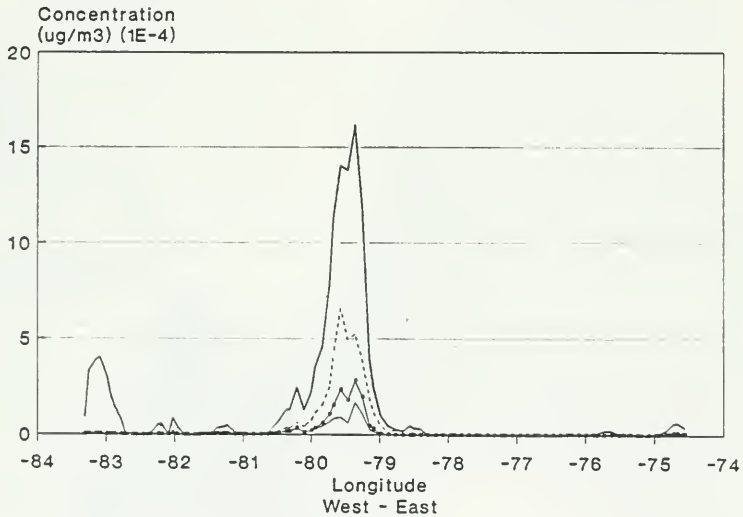


EXHIBIT I.18: PROFILE OF CARBON TETRACHLORIDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Carbon Tetrachloride



Health Threshold = 120 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

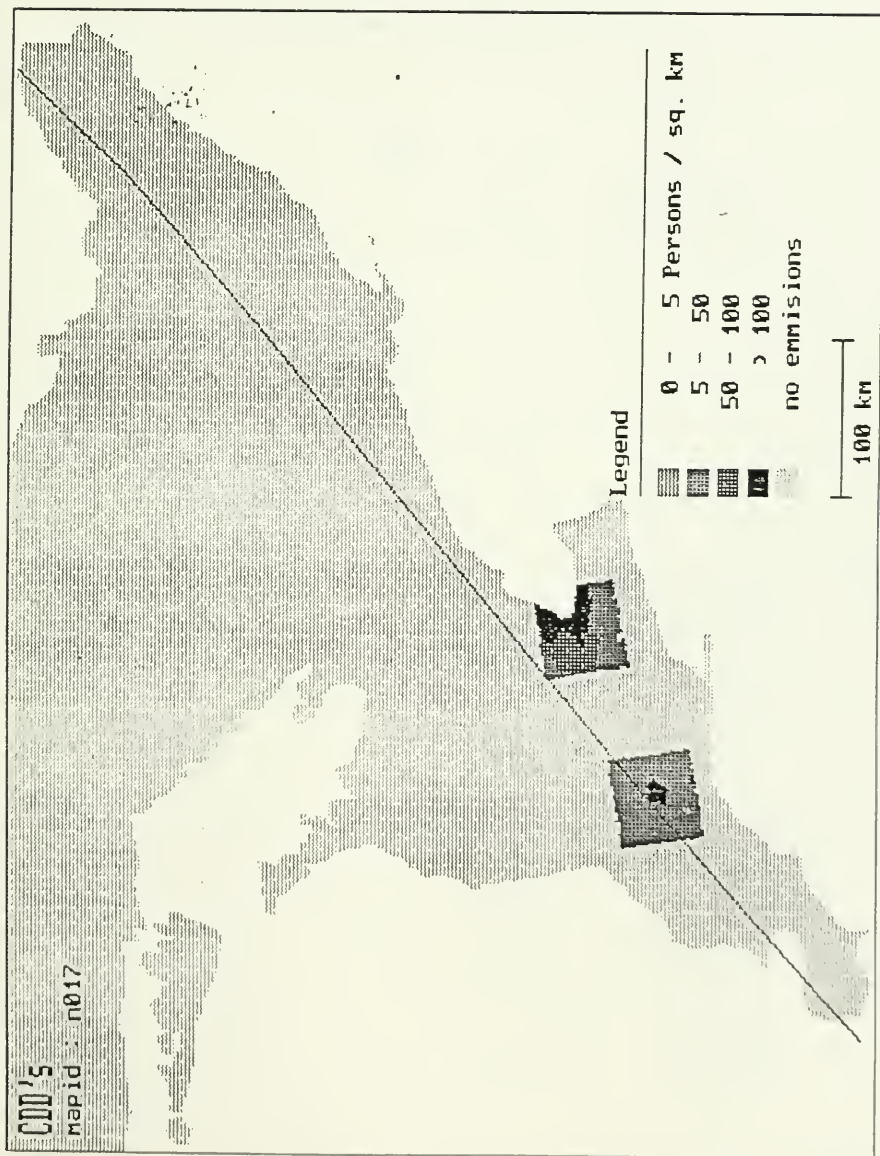
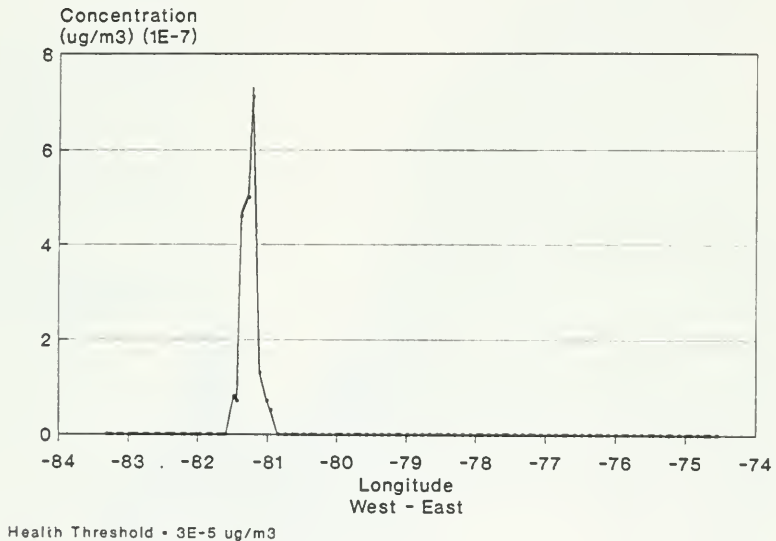


EXHIBIT I.20: PROFILE OF CDD CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

CDD



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	+++++

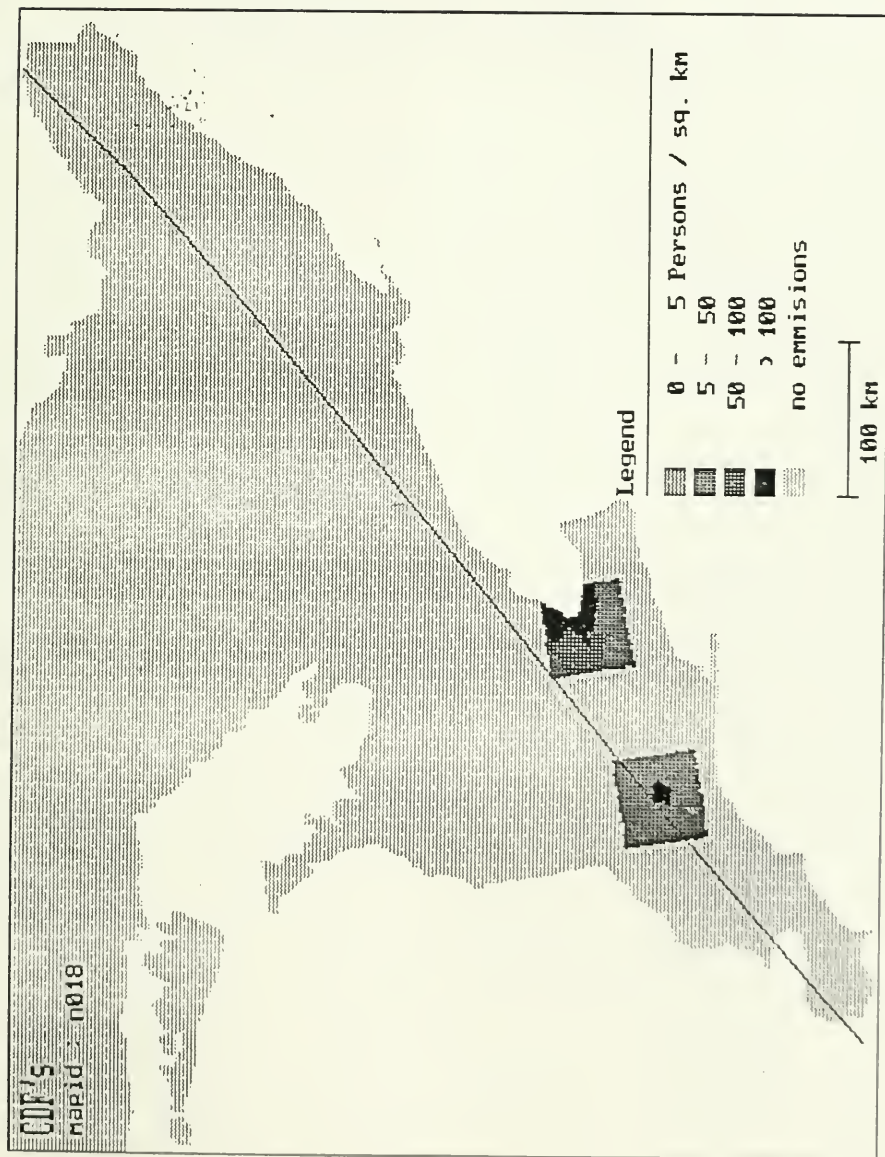
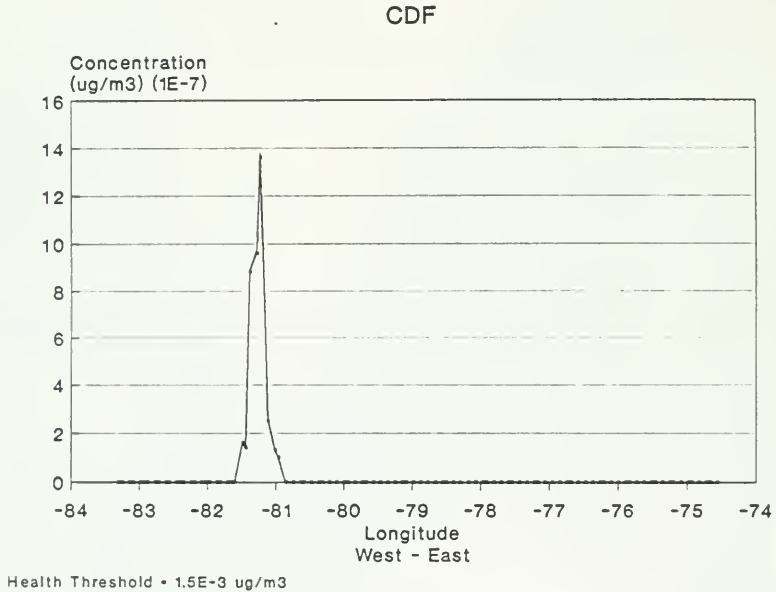


EXHIBIT I.22: PROFILE OF CDF CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C
Scenario E	+++++

EXHIBIT I.23: AREAS EXPOSED TO CHLORINE FROM REGULATION 308 SOURCE EMISSIONS

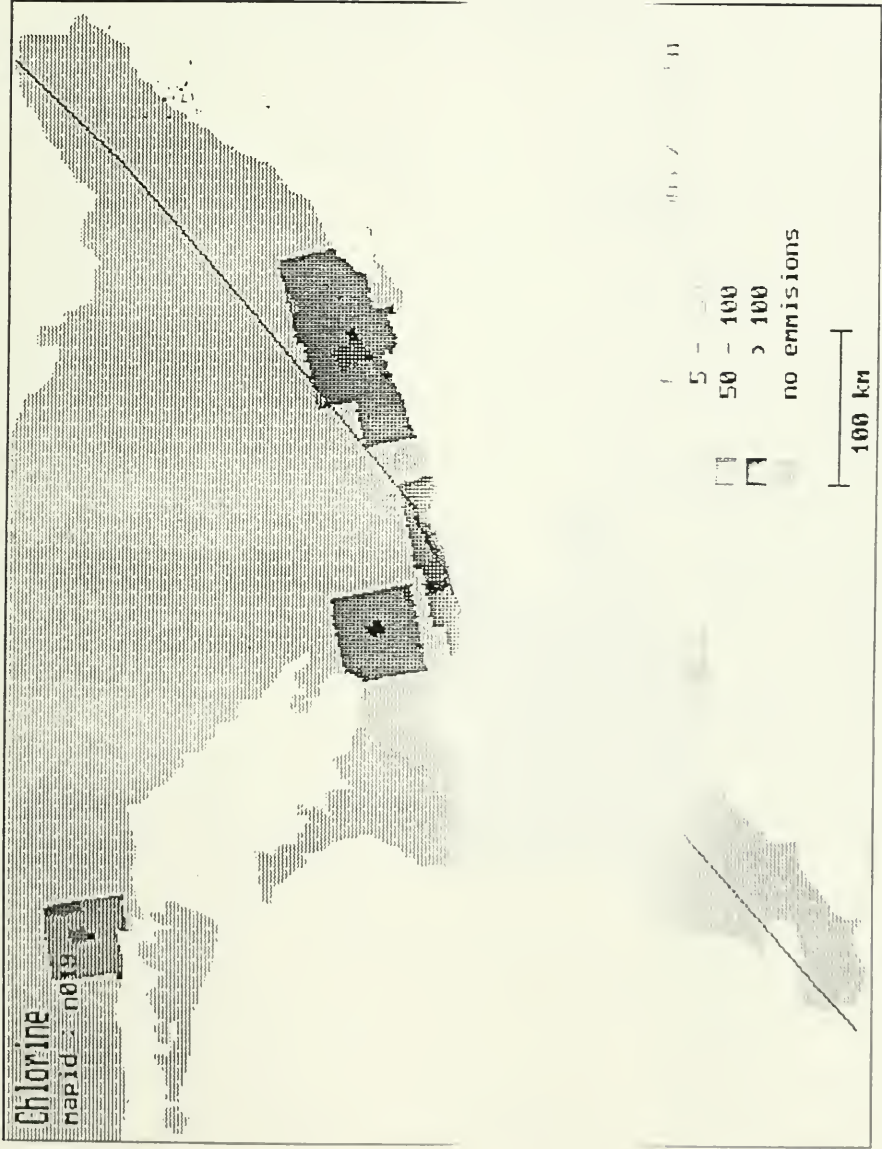
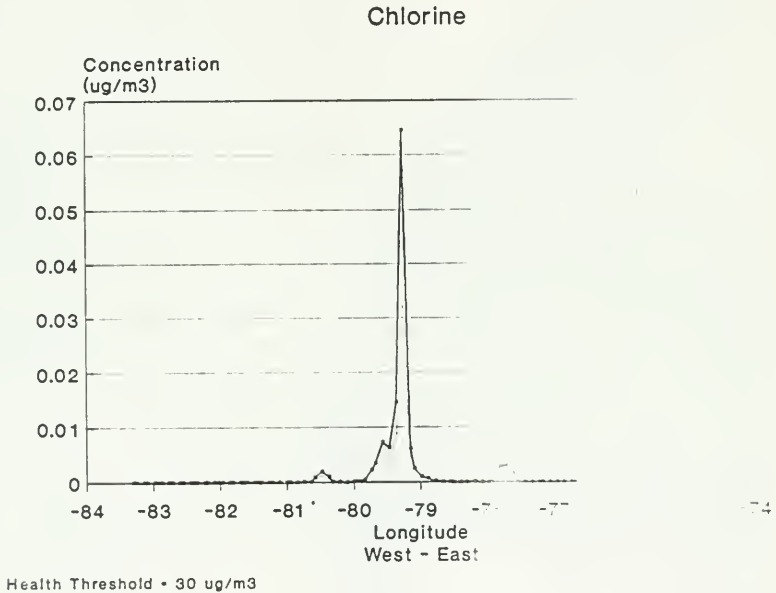


EXHIBIT I.24: PROFILE OF CHLORINE CONCENTRATION AT 308 SOURCE EMISSIONS ACROSS SCENARIOS

REGULATION
10



Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C
Scenario E	+++++

EXHIBIT I.25: AREAS EXPOSED TO CHLORINE DIOXIDE FROM REGULATION 308 SOURCE EMISSIONS

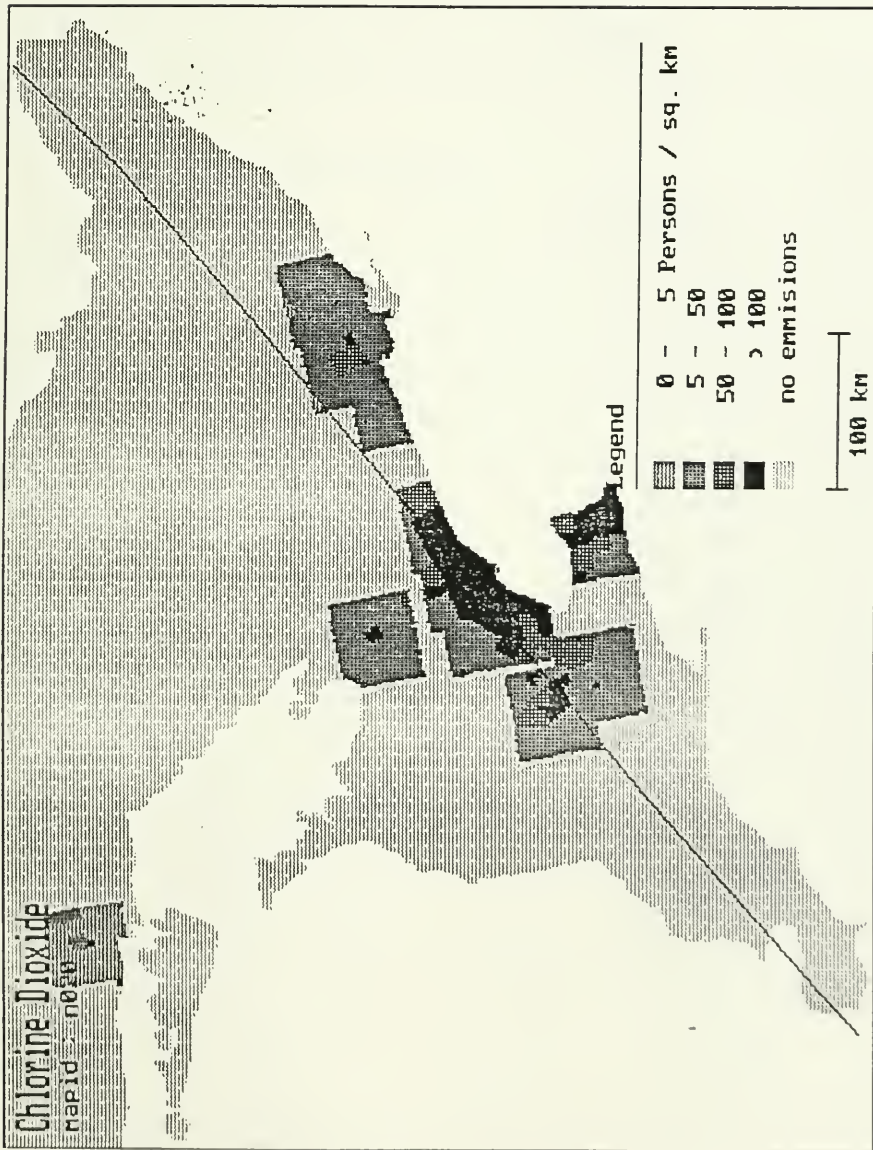
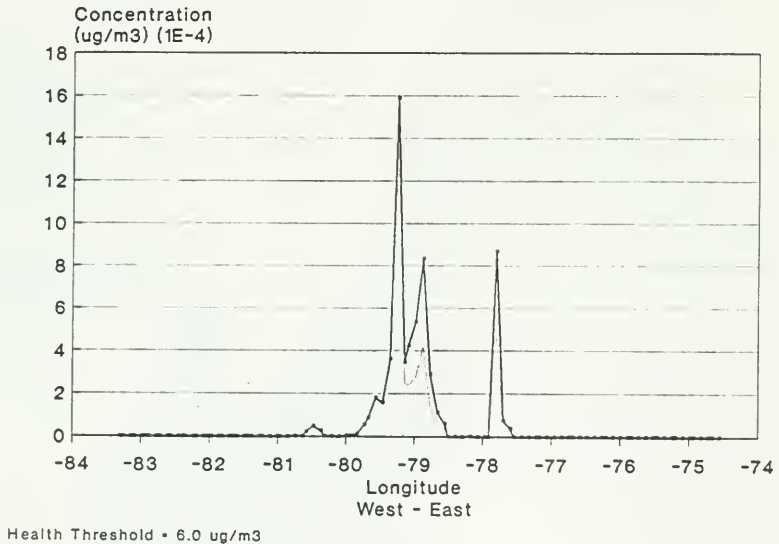


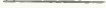




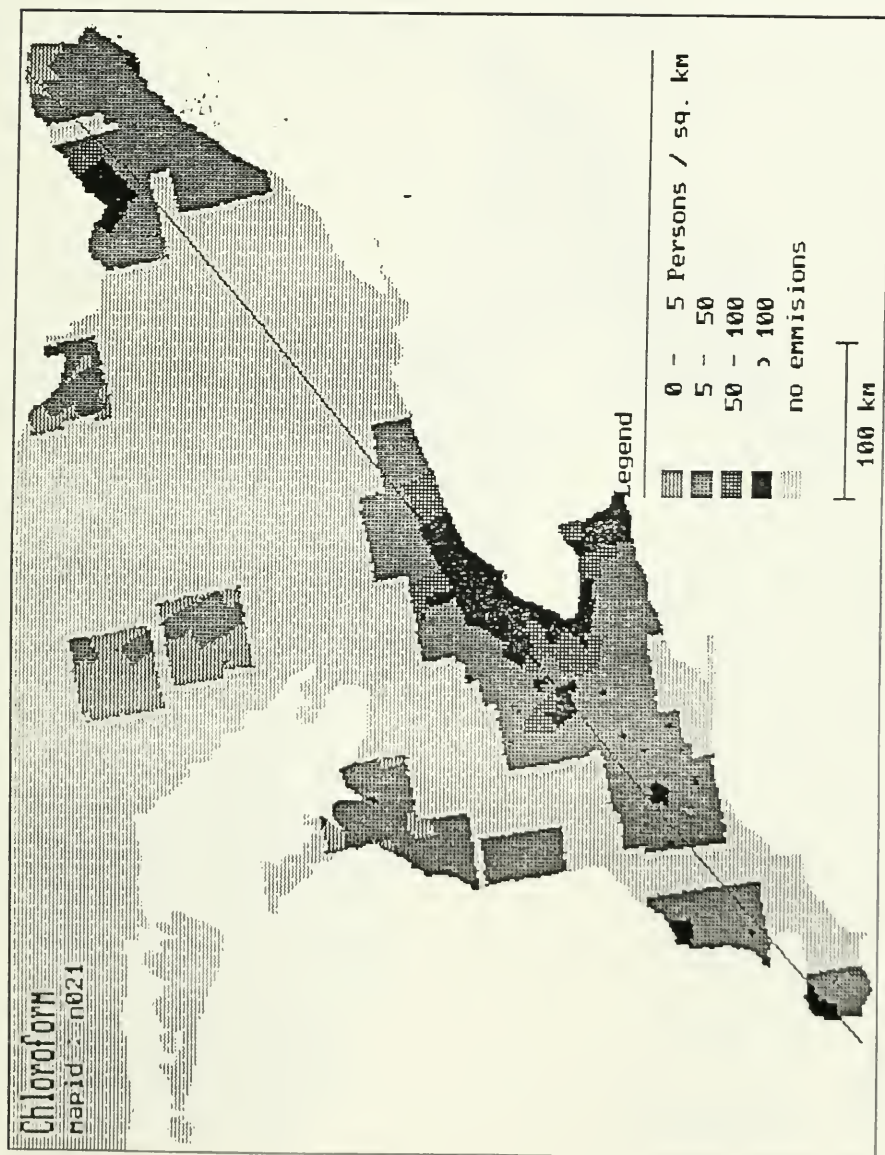
EXHIBIT I.26: PROFILE OF CHLORINE DIOXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

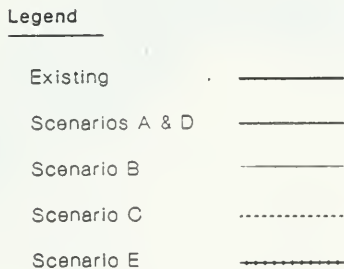
Chlorine Dioxide



Legend

Existing	
Scenarios A & D	
Scenario B	
Scenario C	
Scenario E	





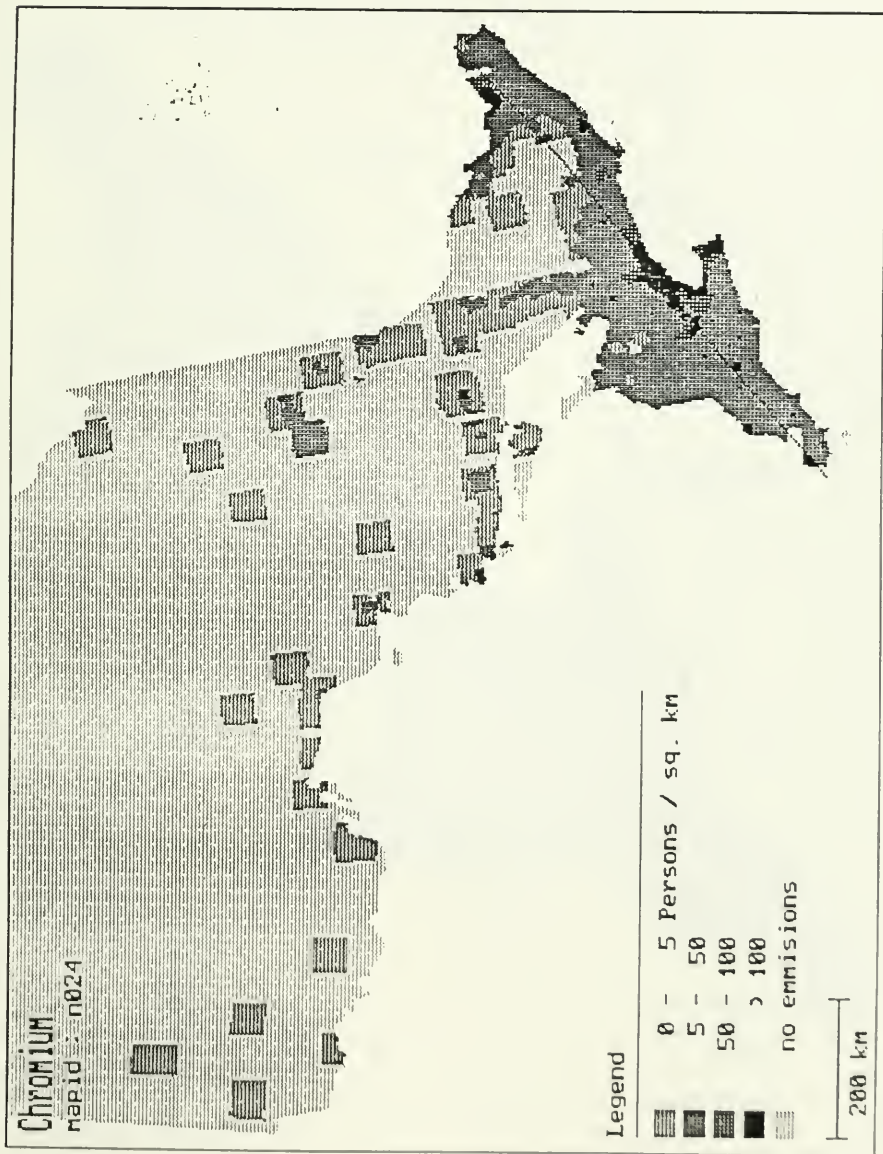
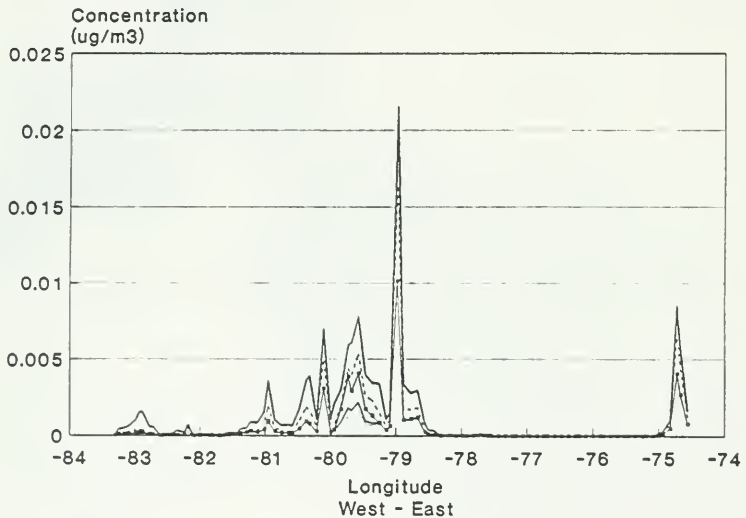


EXHIBIT I.30: PROFILE OF CHROMIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Chromium



Health Threshold = 0.3 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

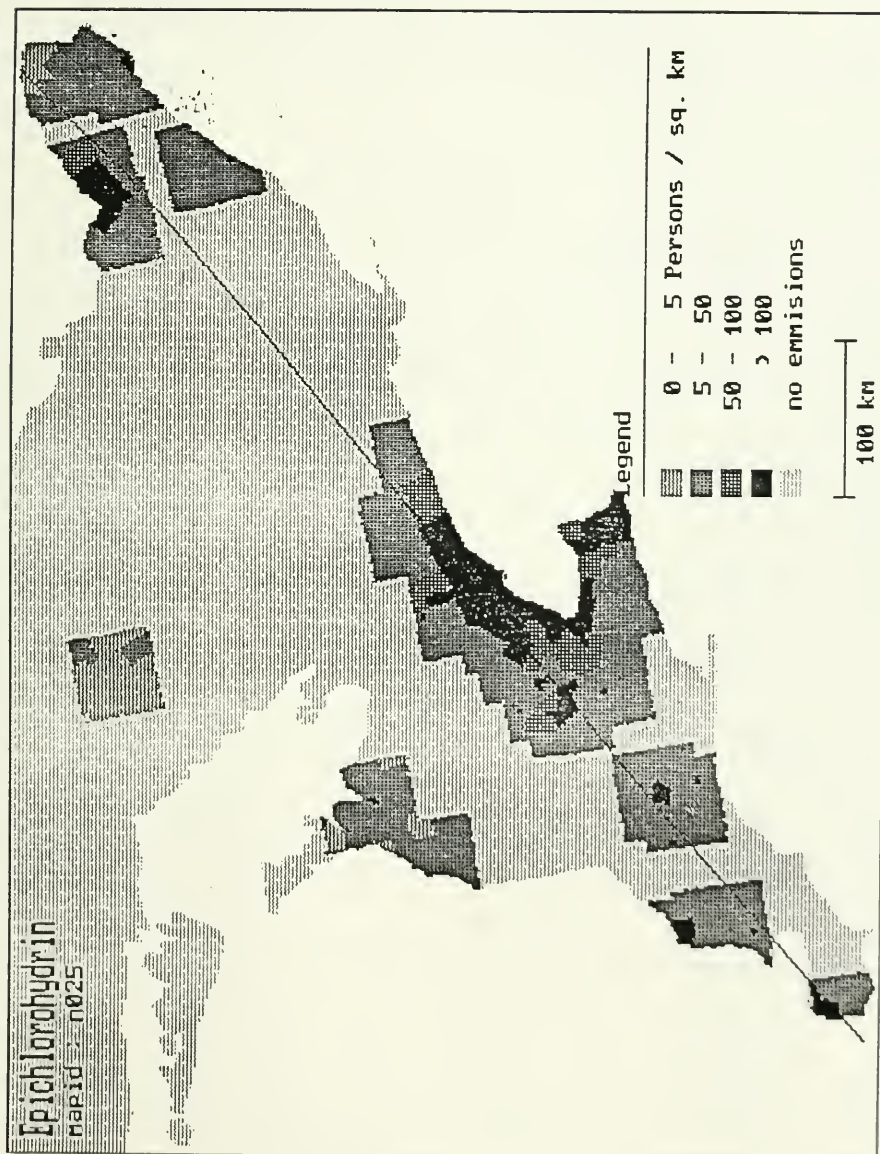
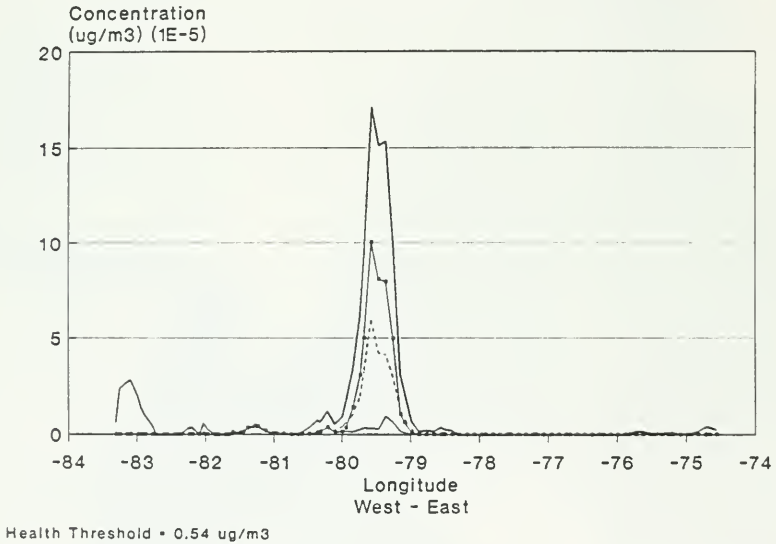


EXHIBIT I.32: PROFILE OF EPICHLOROHYDRIN CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Epichlorohydrin



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

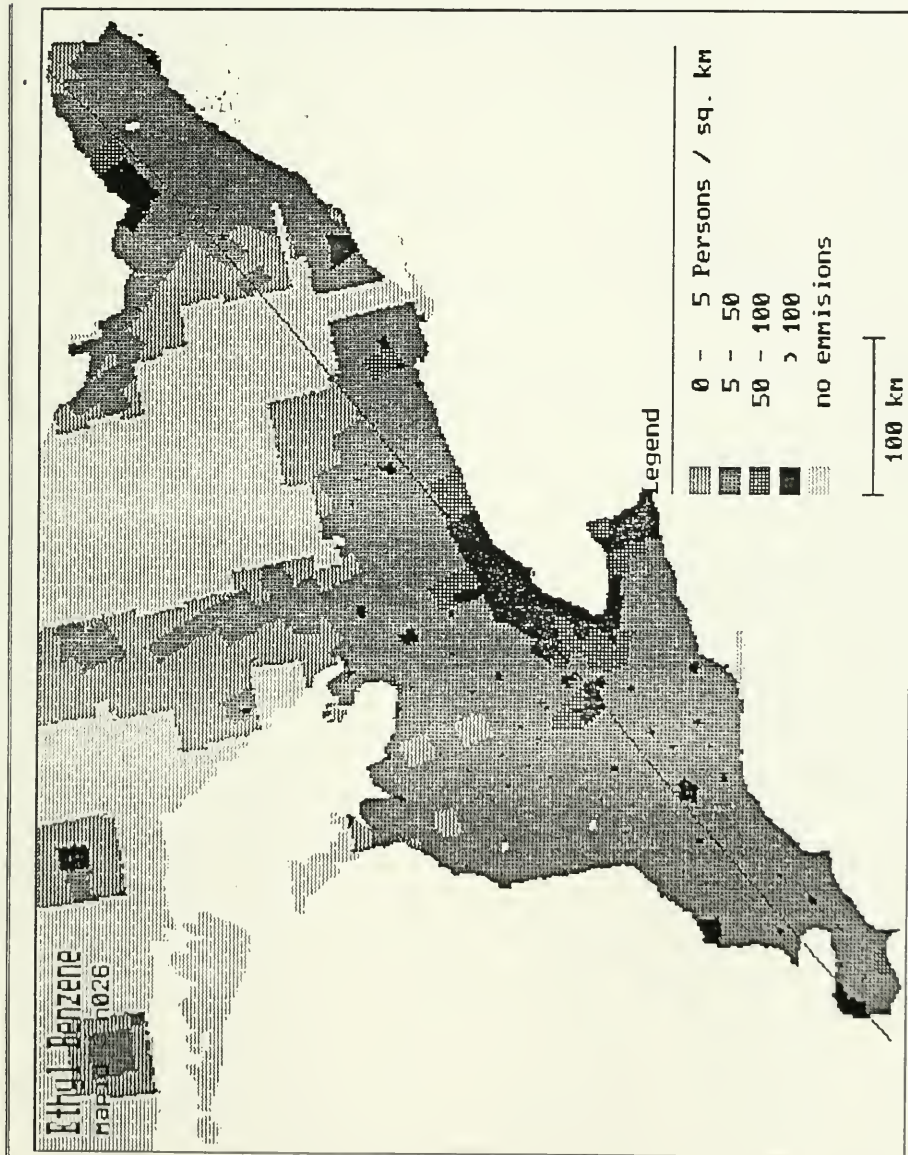
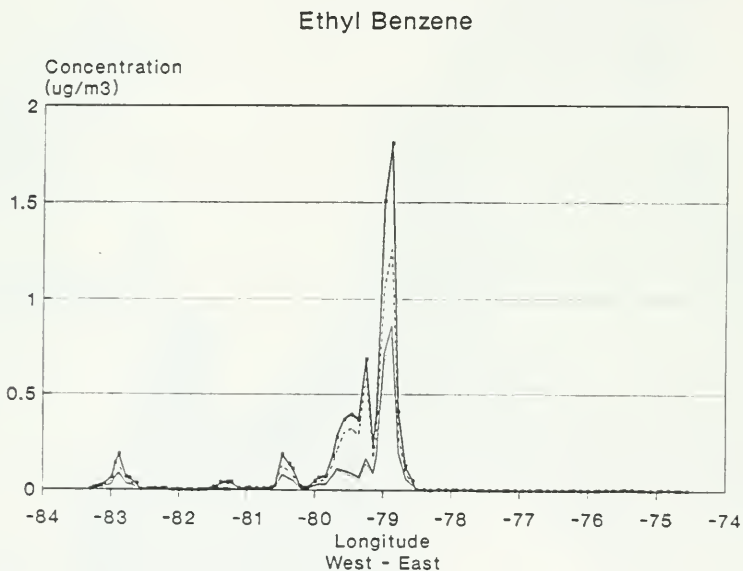


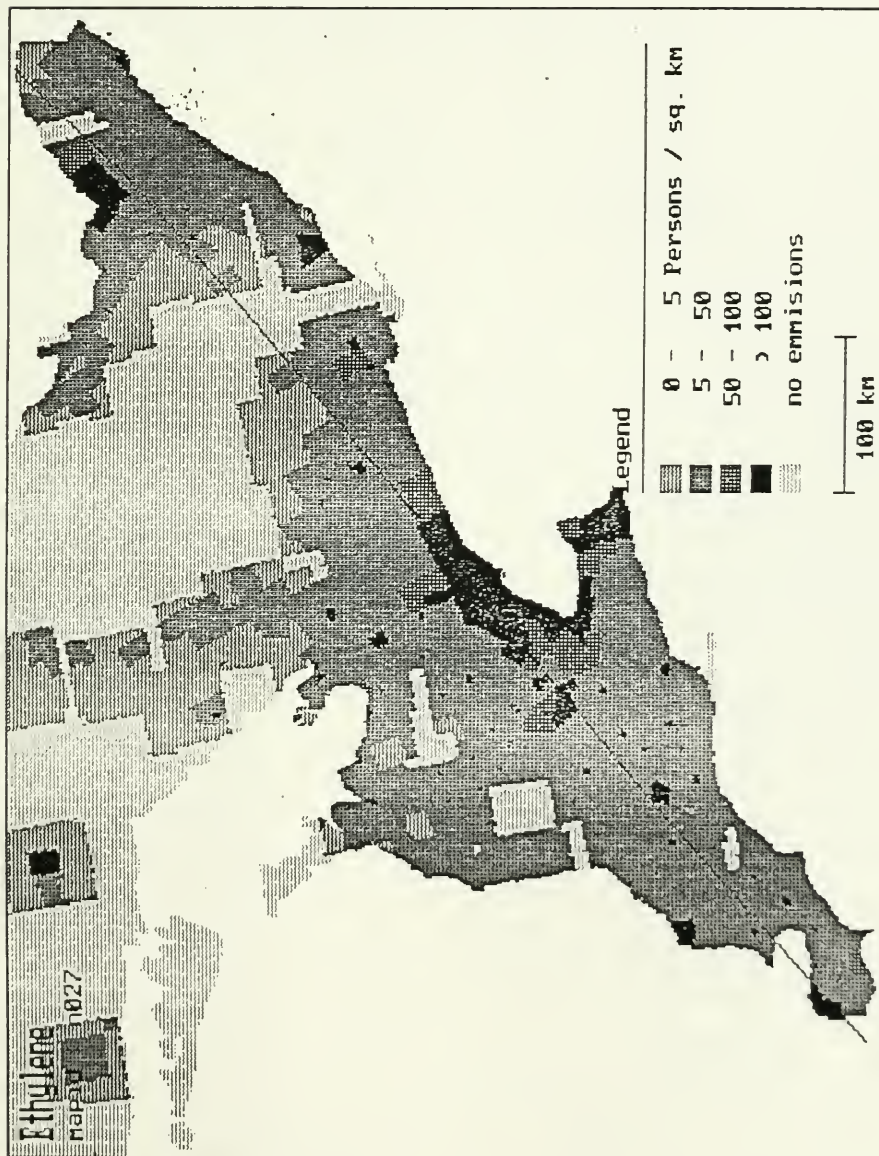
EXHIBIT I.34: PROFILE OF ETHYL BENZENE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



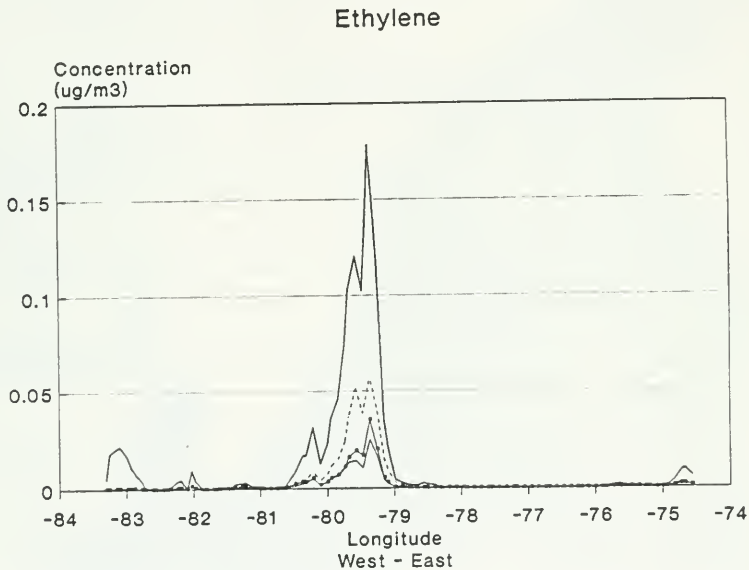
Health Threshold = 0.333 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	+++++



**EXHIBIT I.36: PROFILE OF ETHYLENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO**



Health Threshold = 8 ug/m³

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	•••••

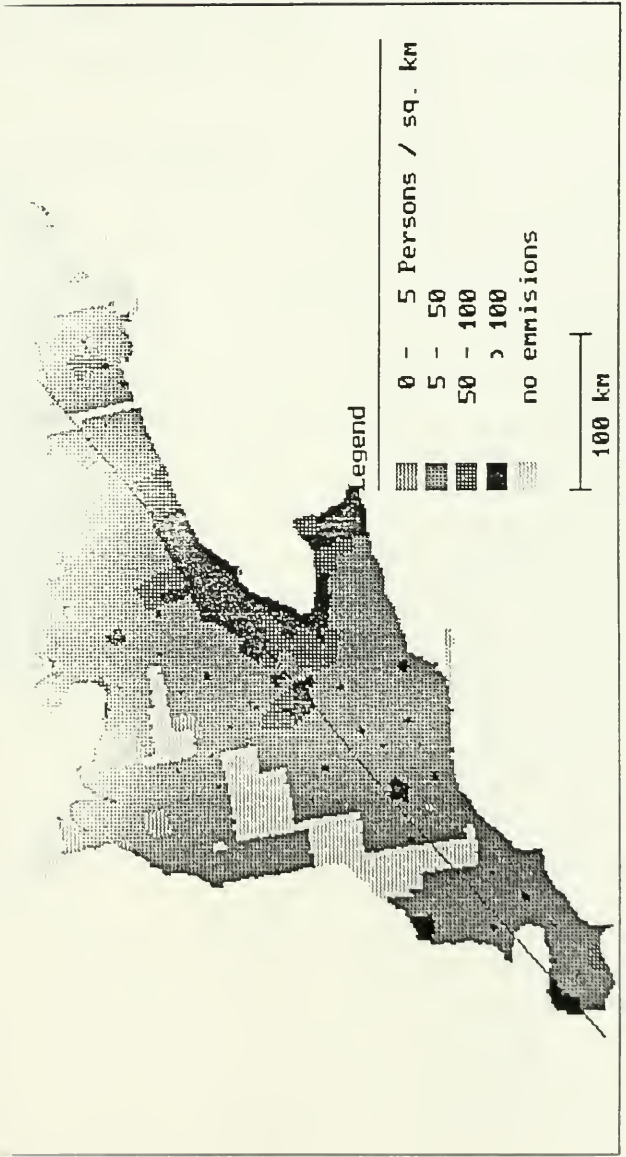
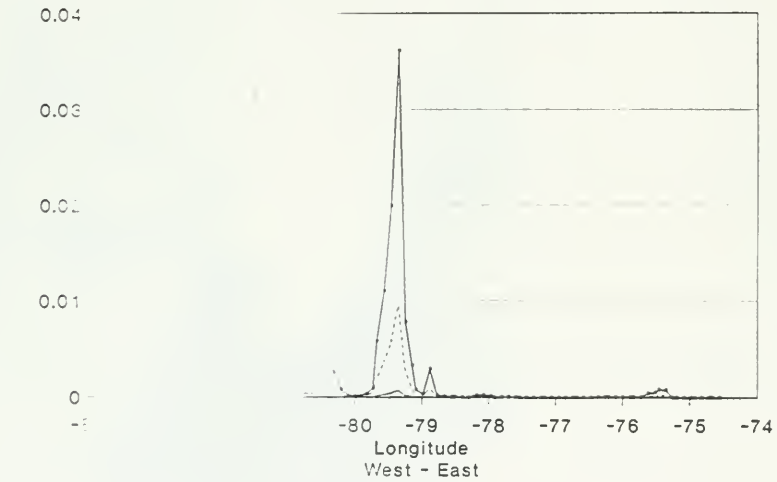


EXHIBIT I.0

ETHYLENE DIBROMIDE CONCENTRATION DUE TO
308 SOURCE EMISSIONS ACROSS SOUTHERN

Ethylene Dibromide



Legend

- Exist: —————
- Scen: —————
- Scen: —————
- Scen: - - - - -
- Scen: - . - . -

EXHIBIT I.39: AREAS EXPOSED TO ETHYLENE DICHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

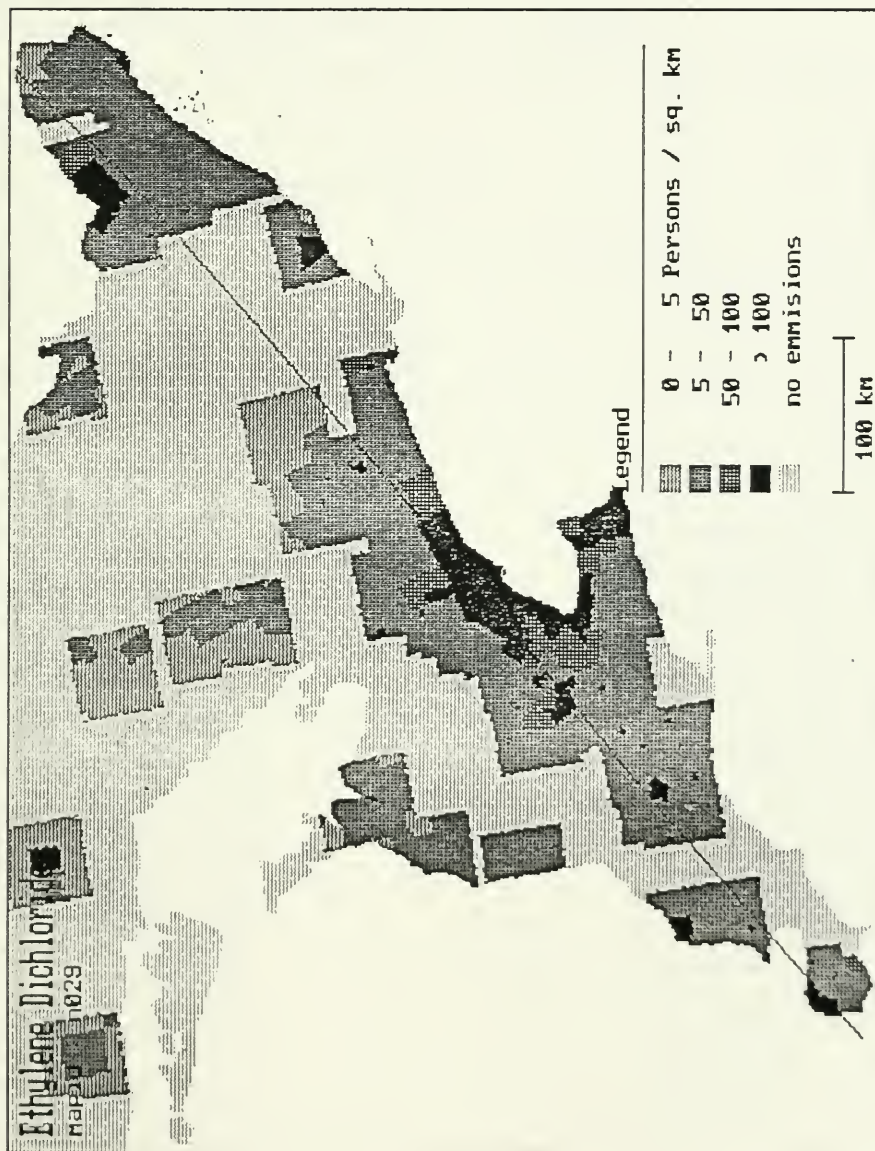
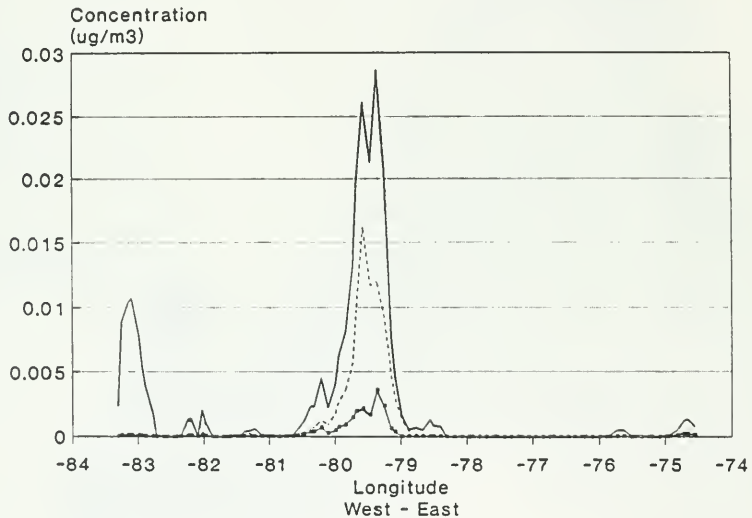


EXHIBIT I.40: PROFILE OF ETHYLENE DICHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Ethylene Dichloride



Health Threshold = 80 $\mu\text{g}/\text{m}^3$

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

EXHIBIT I.41: AREAS EXPOSED TO BUTYL CELLOSOLVE FROM REGULATION 308 SOURCE EMISSIONS

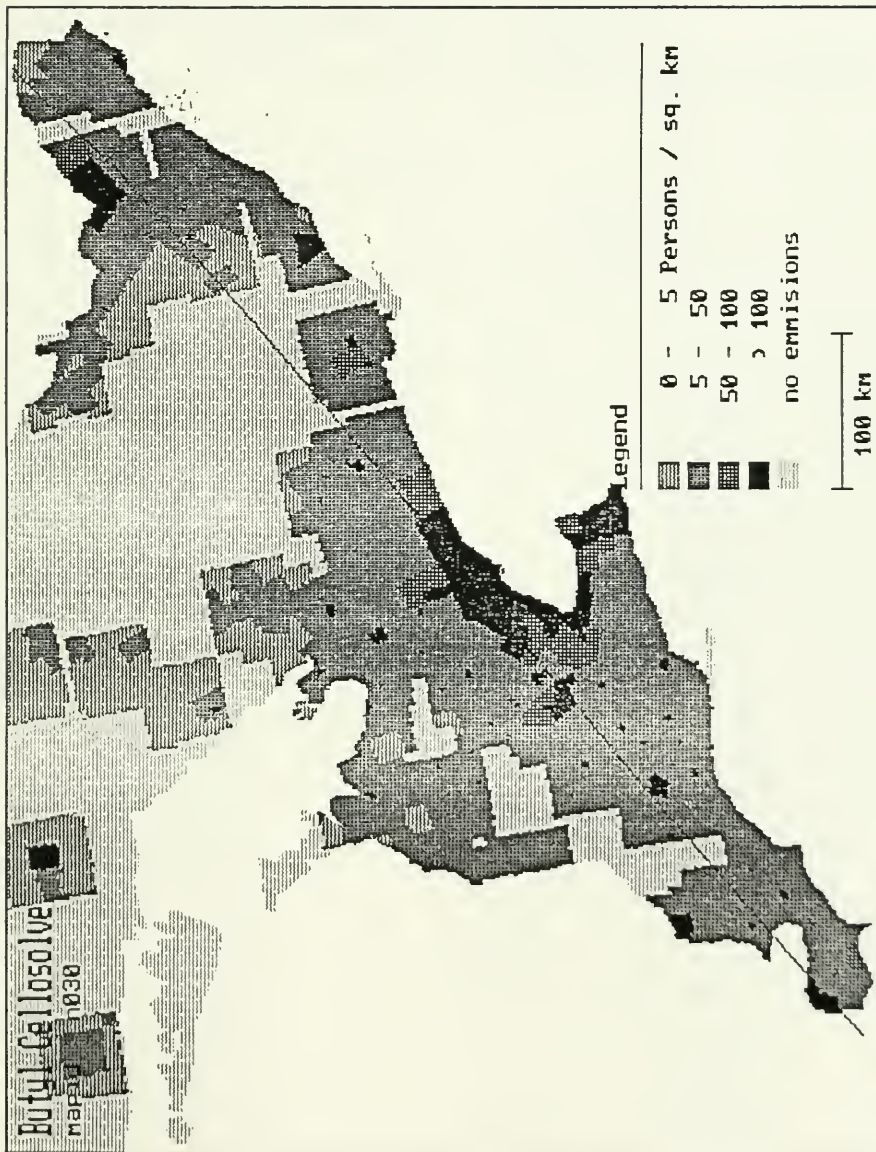
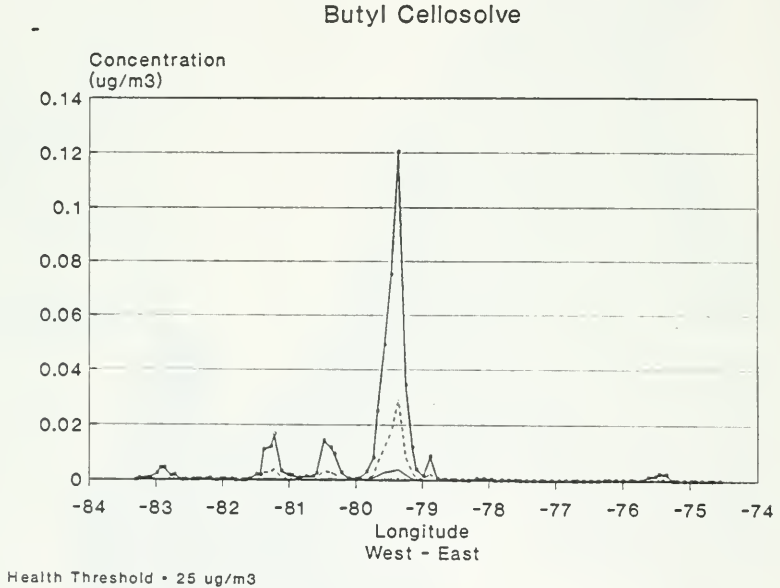


EXHIBIT I.42: PROFILE OF BUTYL CELLOSOLVE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

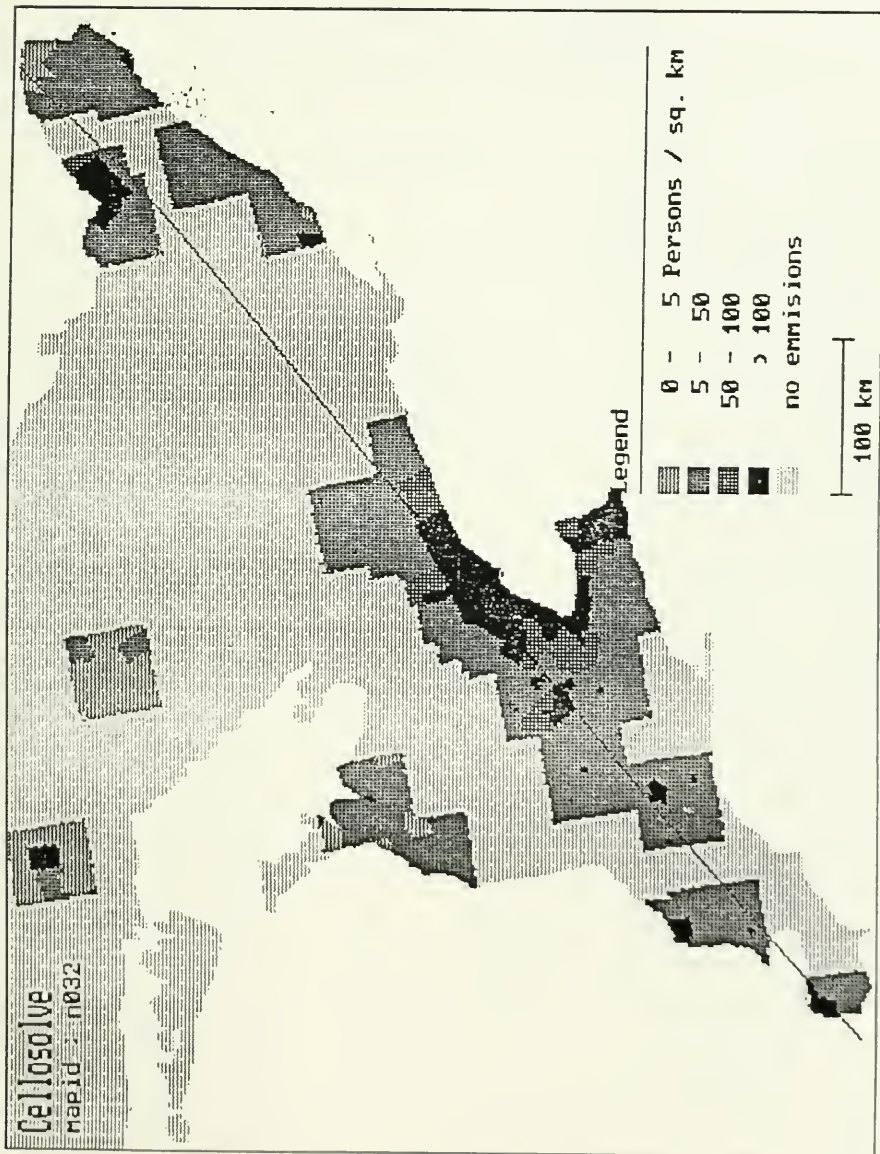
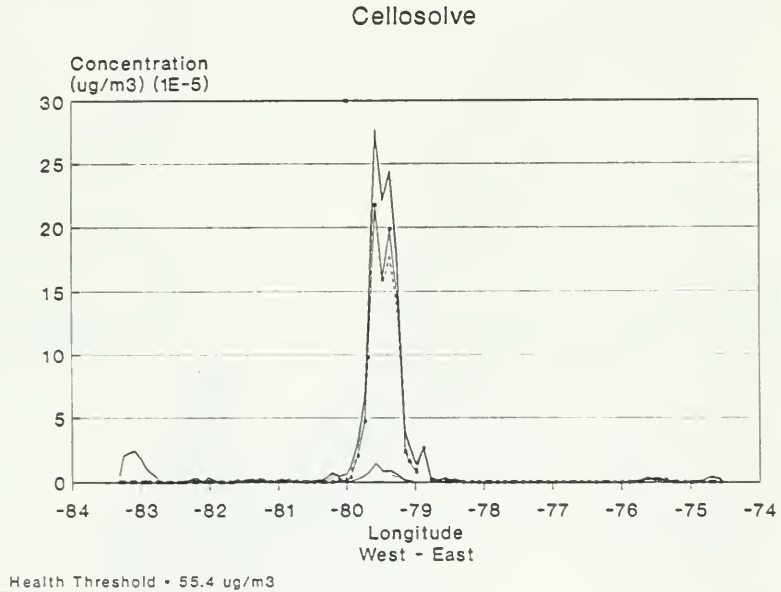


EXHIBIT I.44: PROFILE OF CELLOSOLVE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	-----

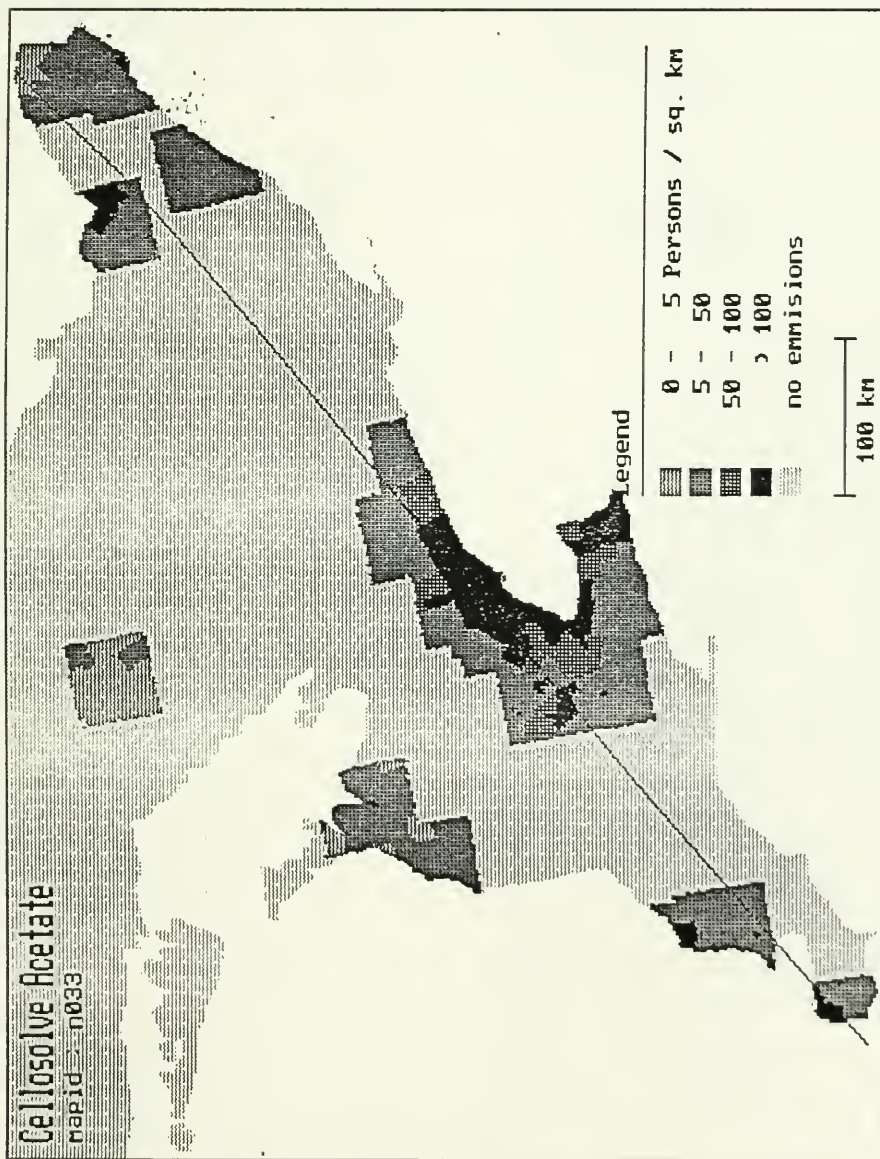
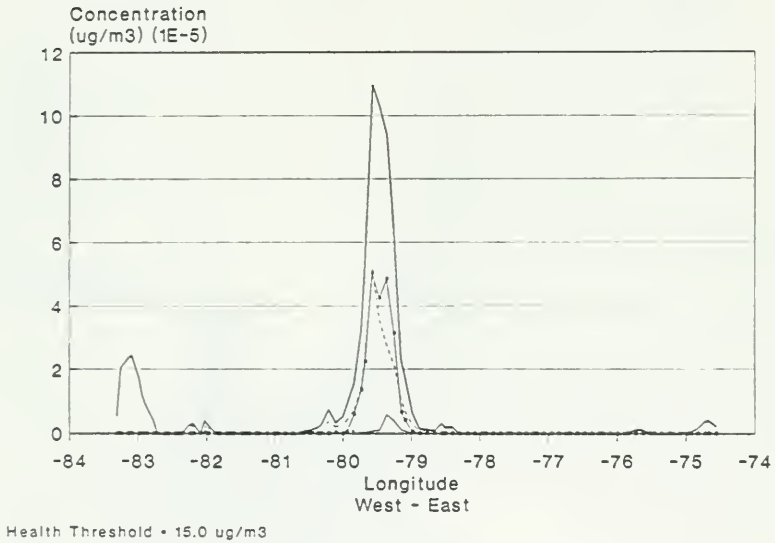


EXHIBIT I.46: PROFILE OF CELLOSOLVE ACETATE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Cellosolve Acetate



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E

EXHIBIT I.47: AREAS EXPOSED TO ETHYLENE OXIDE FROM REGULATION 308 SOURCE EMISSIONS

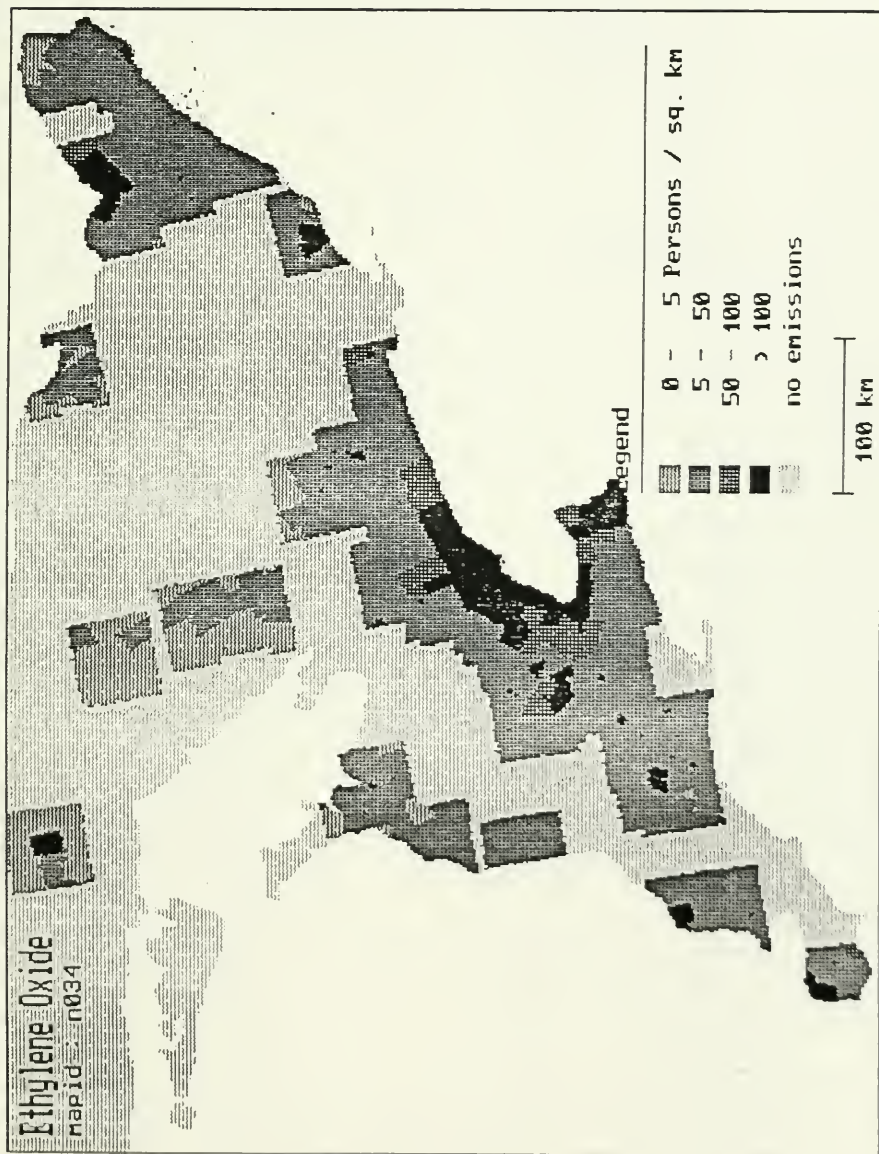
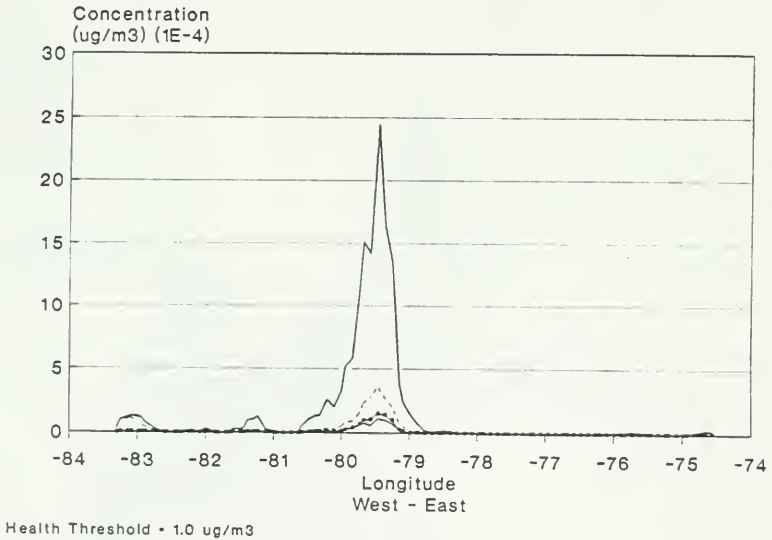


EXHIBIT I.48: PROFILE OF ETHYLENE OXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Ethylene Oxide



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

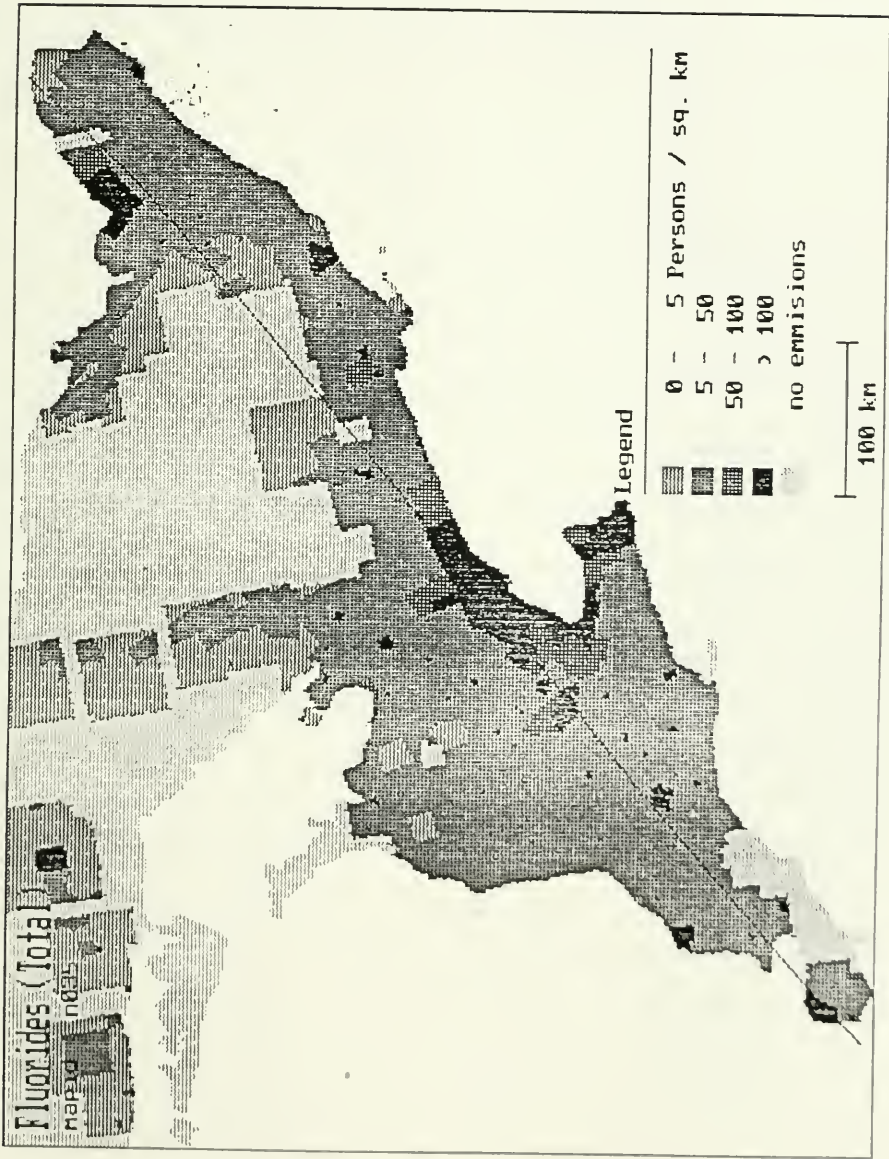
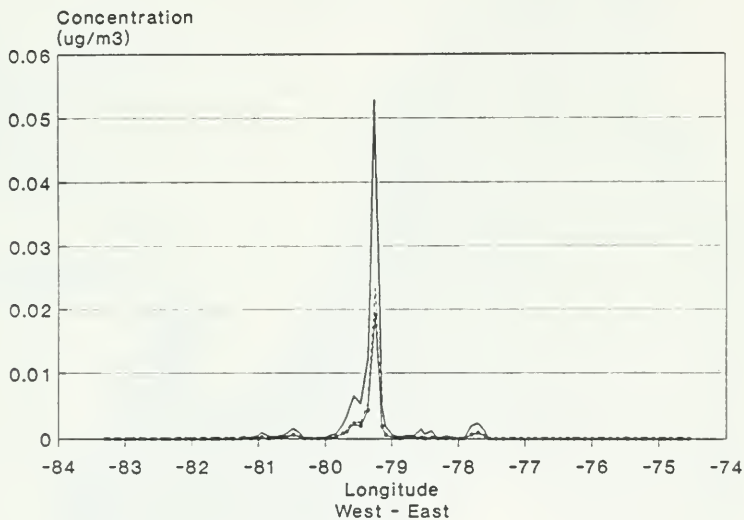


EXHIBIT I.50: PROFILE OF FLUORIDES CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

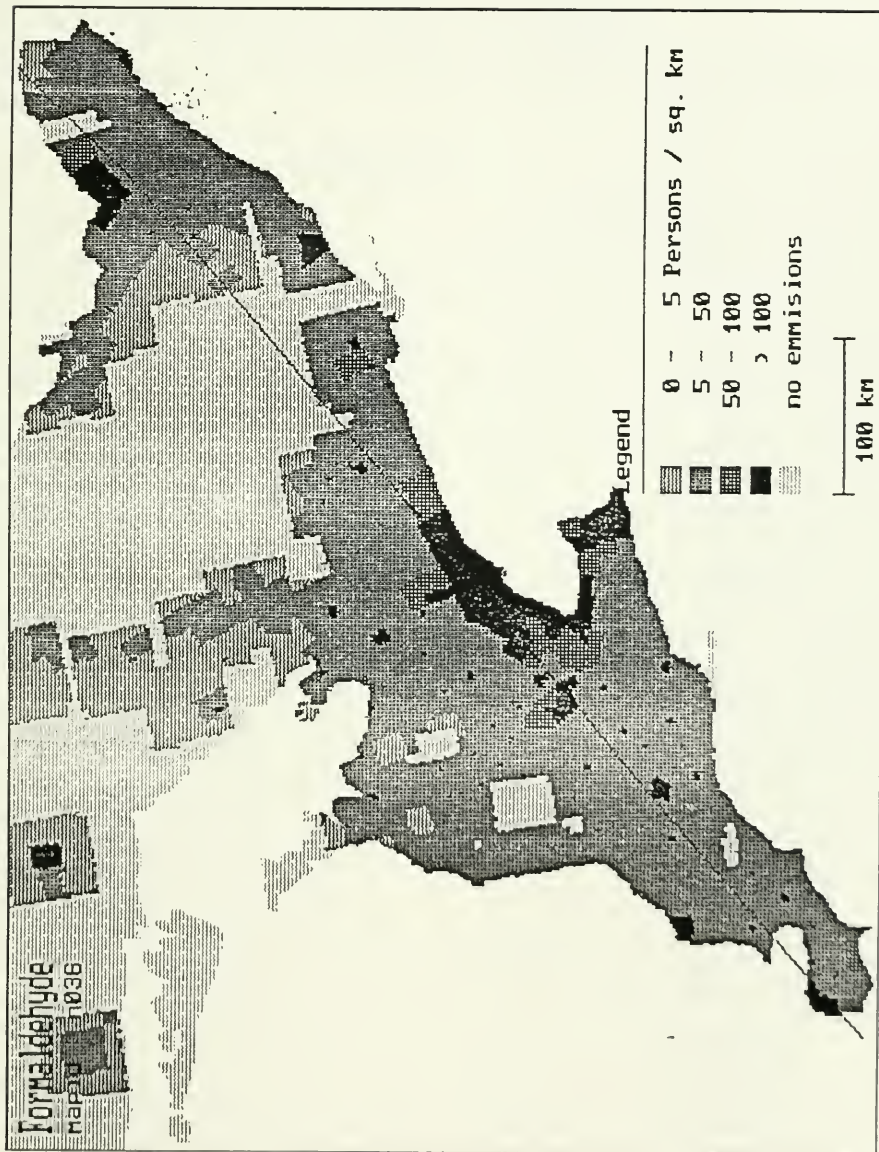
Fluorides



Health Threshold = 0.344 ug/m³

Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C	-----
Scenario E



Legend

Existing

Scenarios A & D

Scenario B

Scenario C

Scenario E

EXHIBIT I.53: AREAS EXPOSED TO HYDROGEN CHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

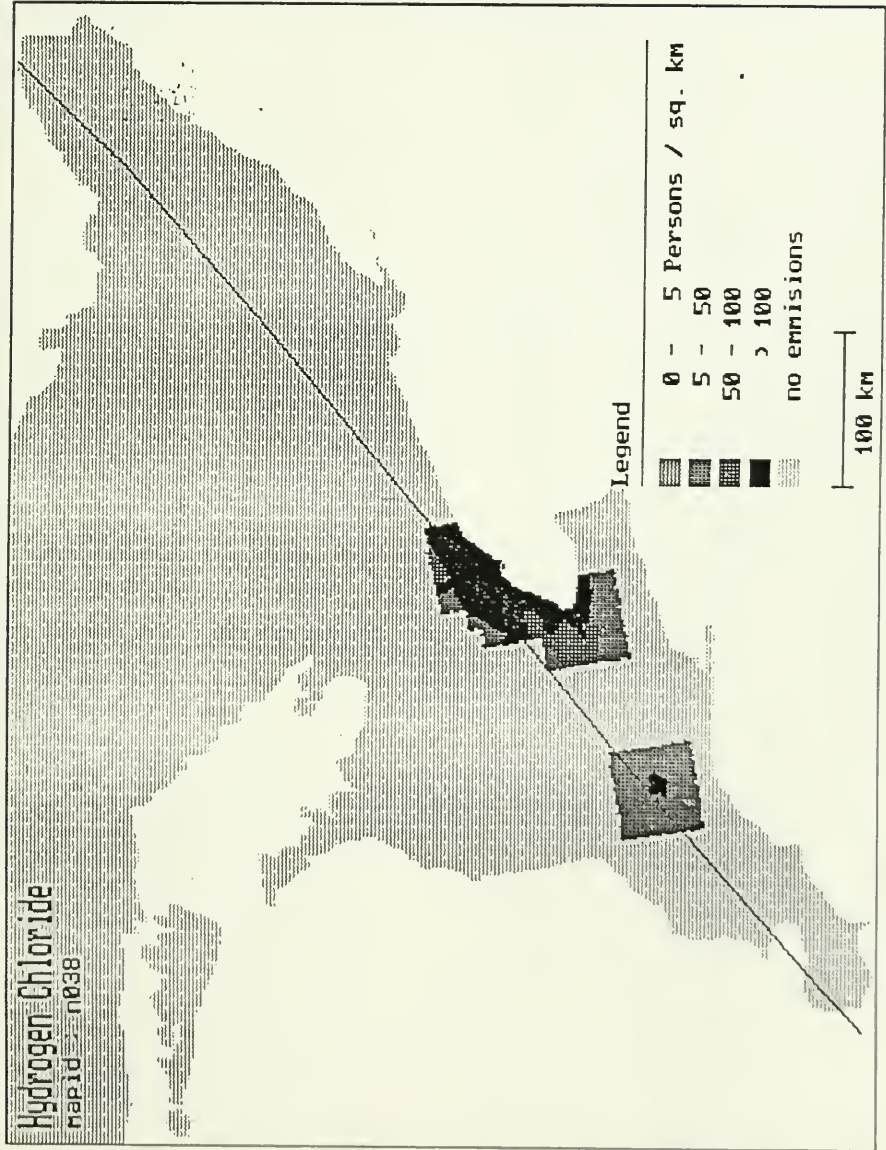
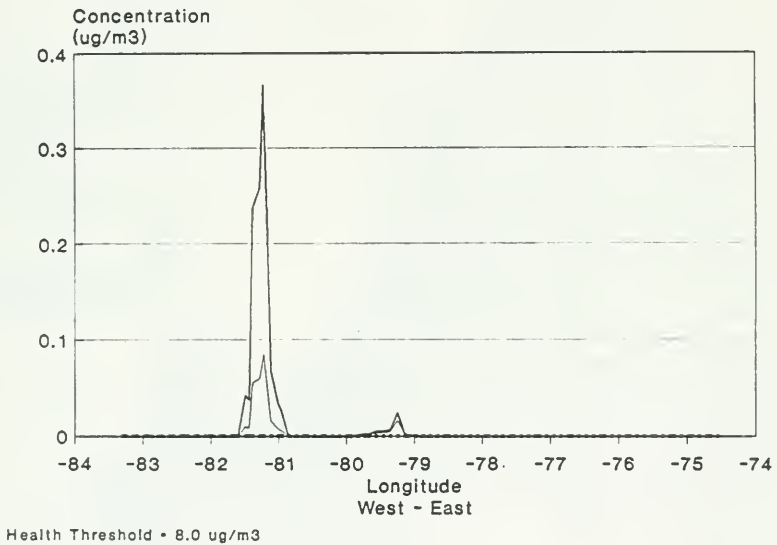


EXHIBIT I.54: PROFILE OF HYDROGEN CHLORIDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Hydrogen Chloride



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C
Scenario E

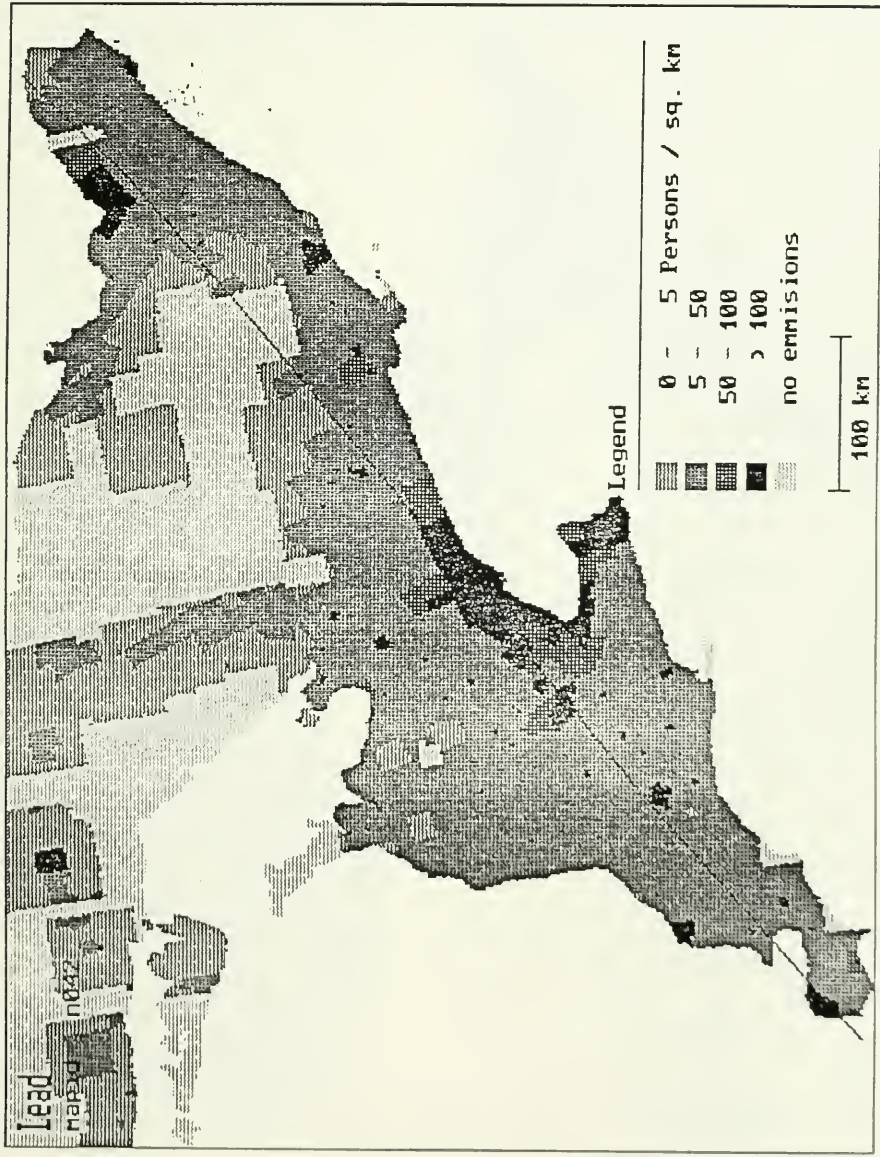
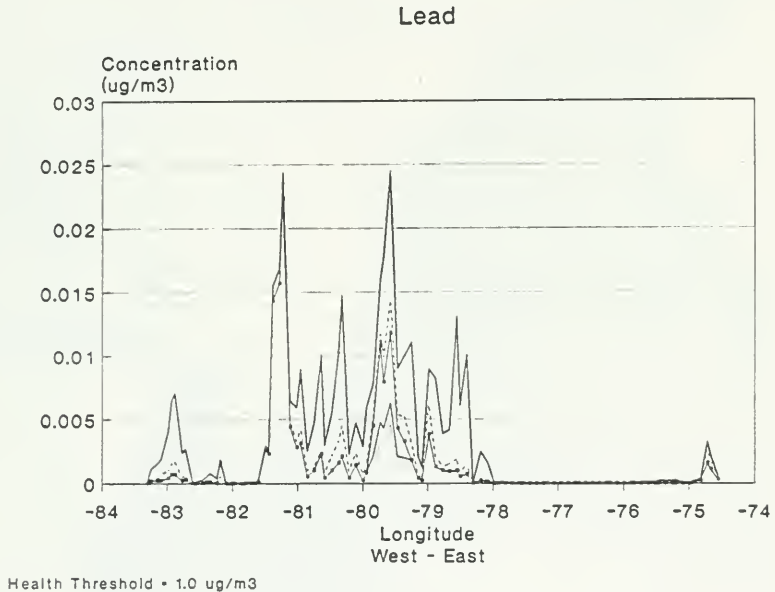


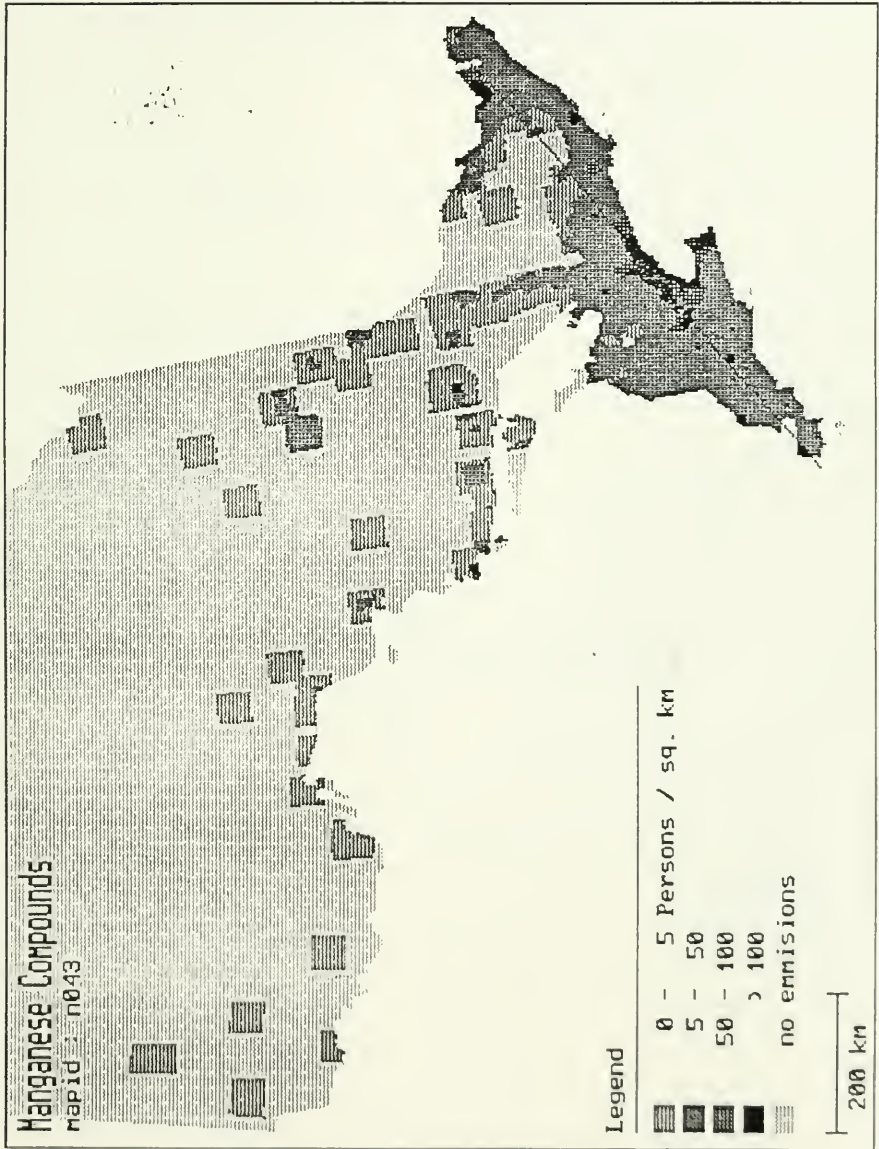
EXHIBIT I.56: PROFILE OF LEAD CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C
Scenario E	+++++

EXHIBIT I.57: AREAS EXPOSED TO MANGANESE COMPOUNDS FROM REGULATION 308 SOURCE EMISSIONS



Concentration (ug/m3)

0.12

0.1

0.08

0.06

0.04

0.02

0

-84 -83 -82 -81 -80 -79 -78 -77 -76 -75 -74

Longitude West - East

Legend

Existing

Scenarios A & D

Scenario B

Scenario C

Scenario E

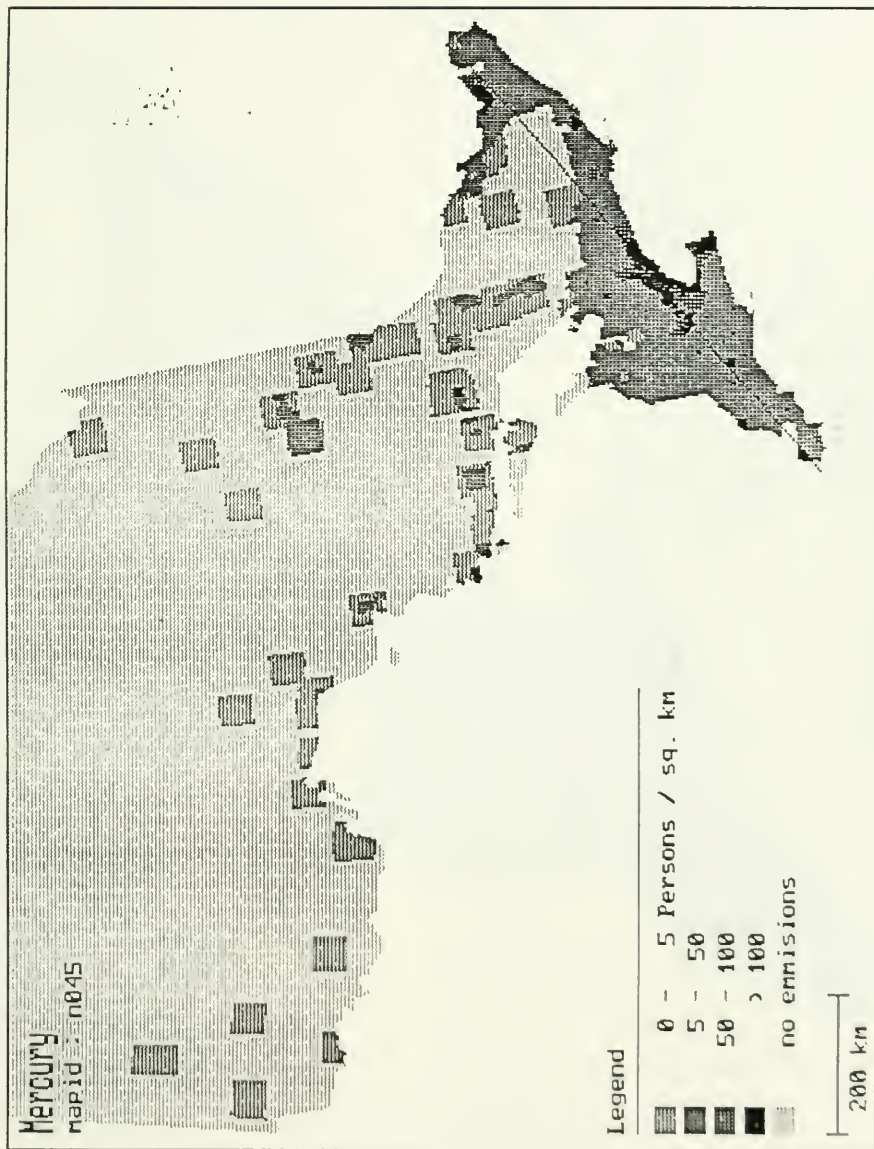
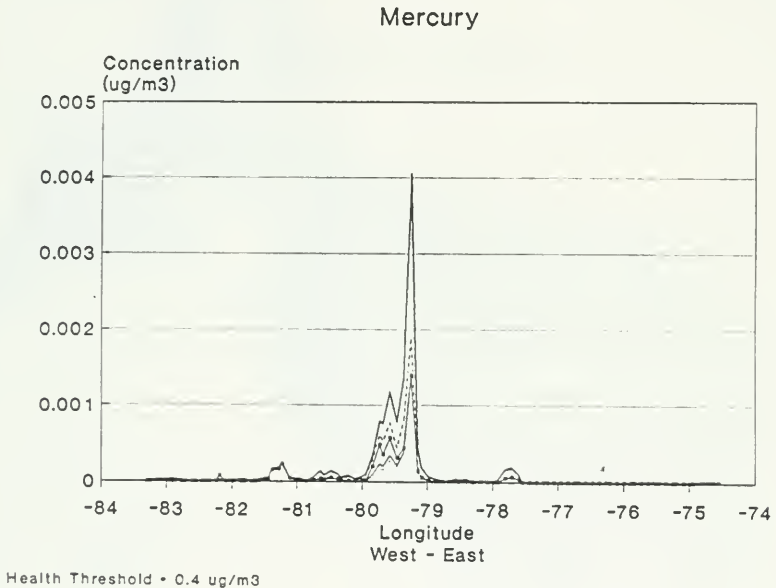


EXHIBIT I.60: PROFILE OF MERCURY CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	
Scenarios A & D	
Scenario B	
Scenario C	
Scenario E	

EXHIBIT I.61: AREAS EXPOSED TO METHYL ISOBUTYL KETONE FROM REGULATION 308 SOURCE EMISSIONS

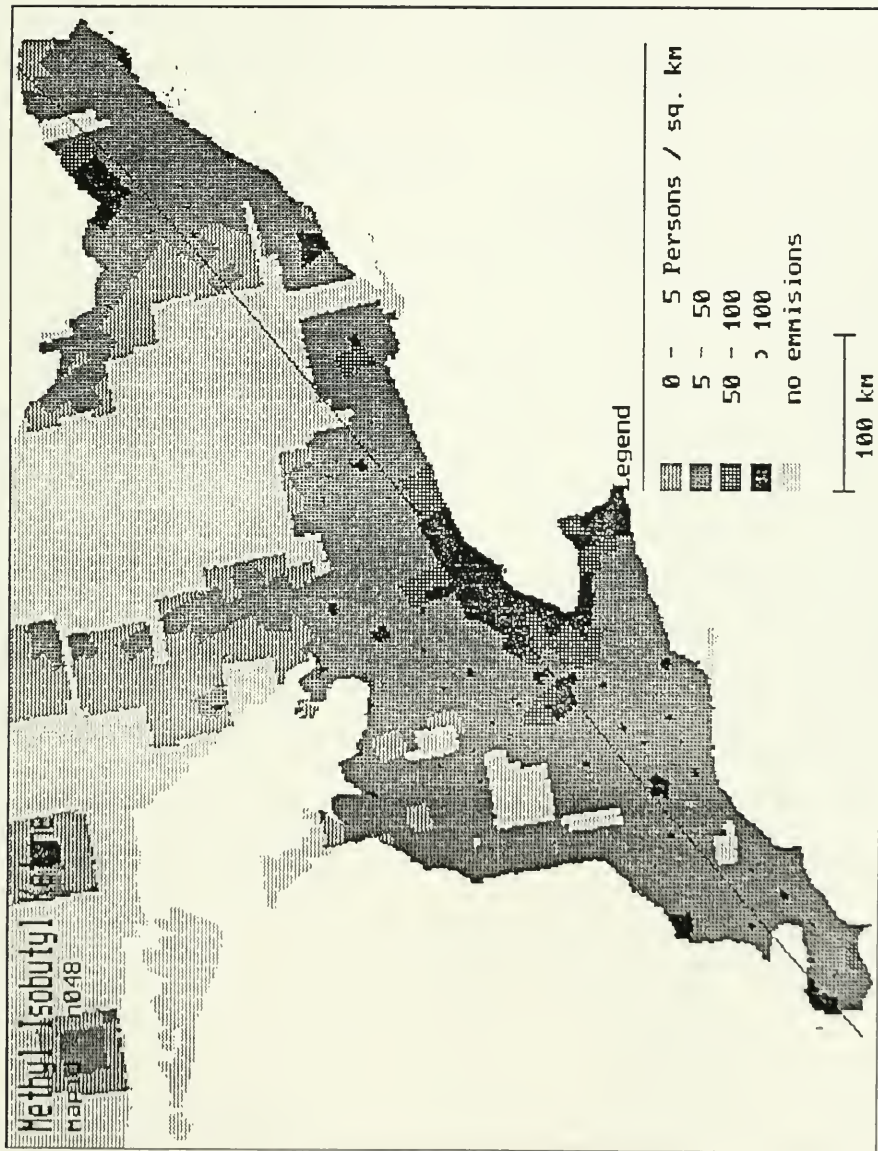
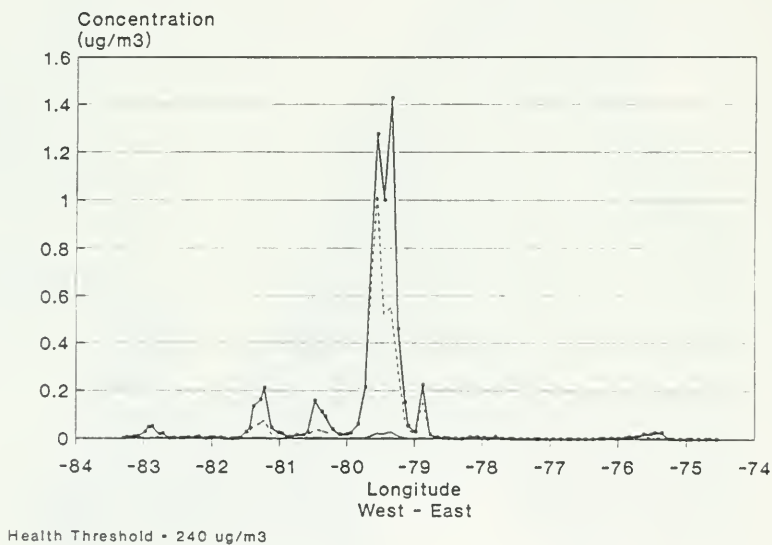


EXHIBIT I.62: PROFILE OF METHYL ISOBUTYL KETONE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Methyl Isobutyl Ketone



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

EXHIBIT I.63: AREAS EXPOSED TO METHYLENE CHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

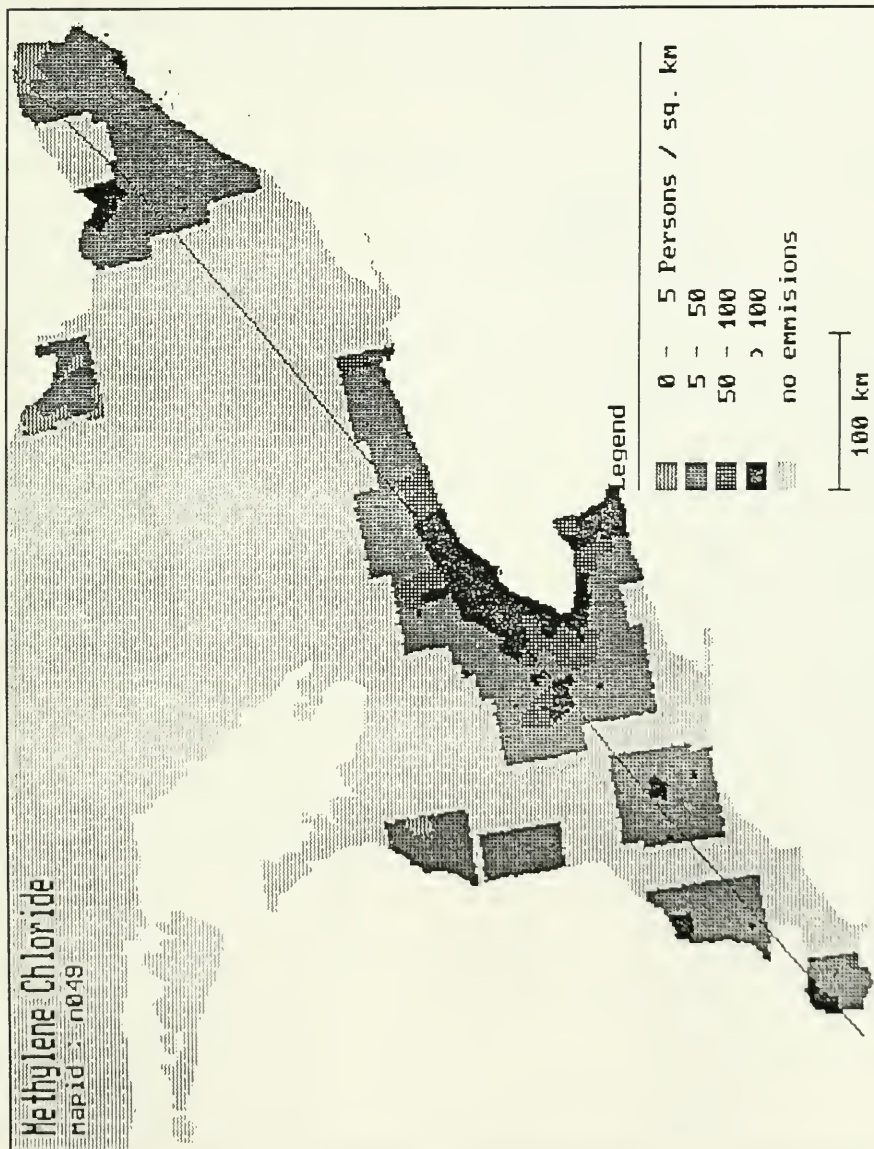
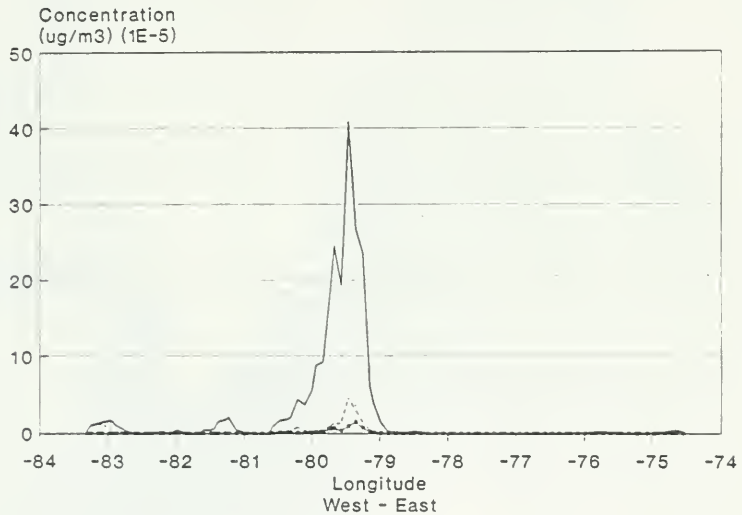


EXHIBIT I.64: PROFILE OF METHYLENE CHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Methylene Chloride



Health Threshold = 583 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

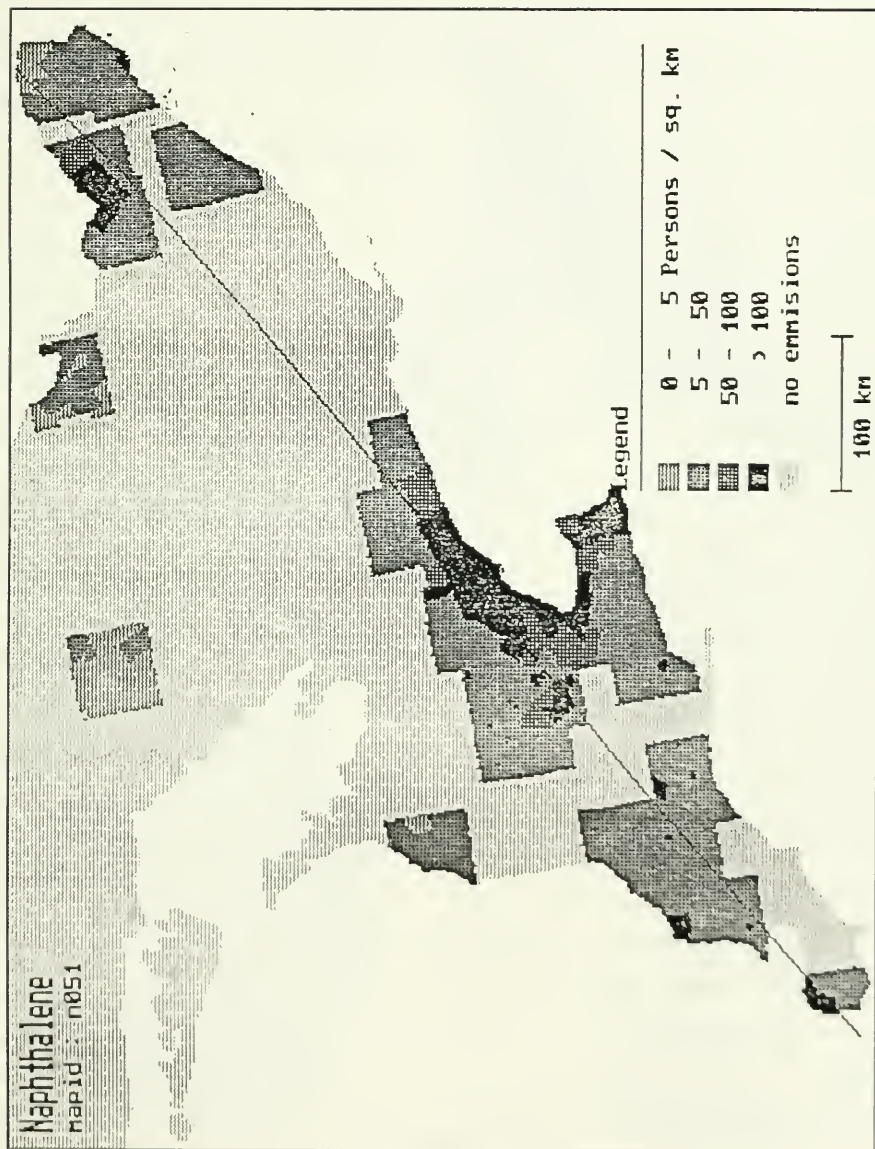
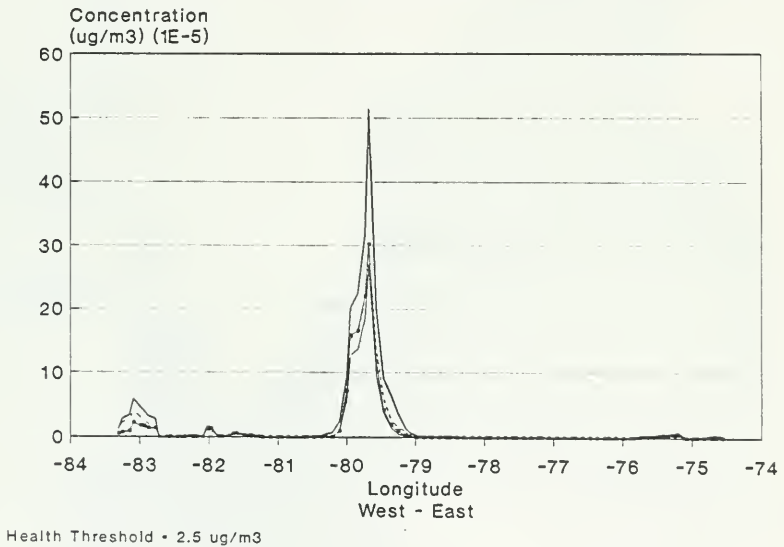


EXHIBIT I.66: PROFILE OF NAPHTHALENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Naphthalene



Legend

Existing	—————
Scenarios A & D	-----
Scenario B
Scenario C
Scenario E	- . - . - .

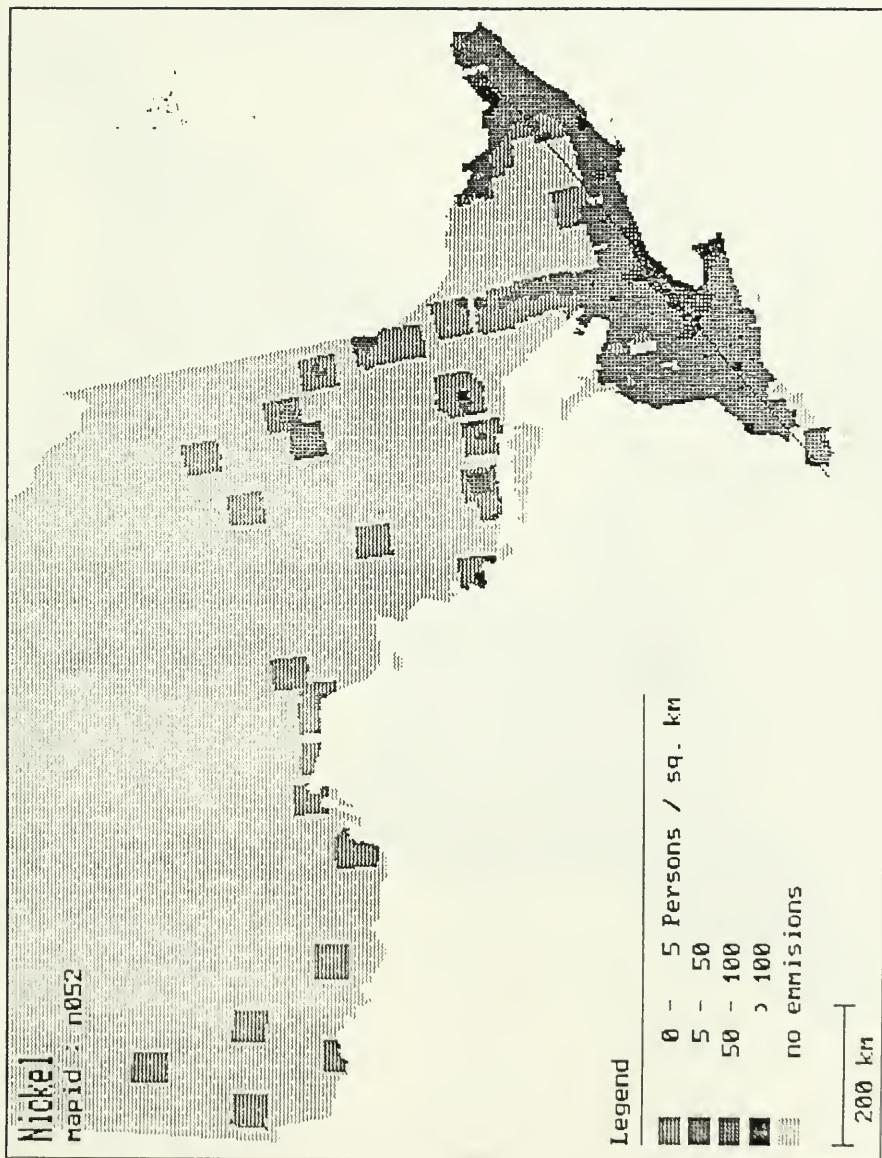
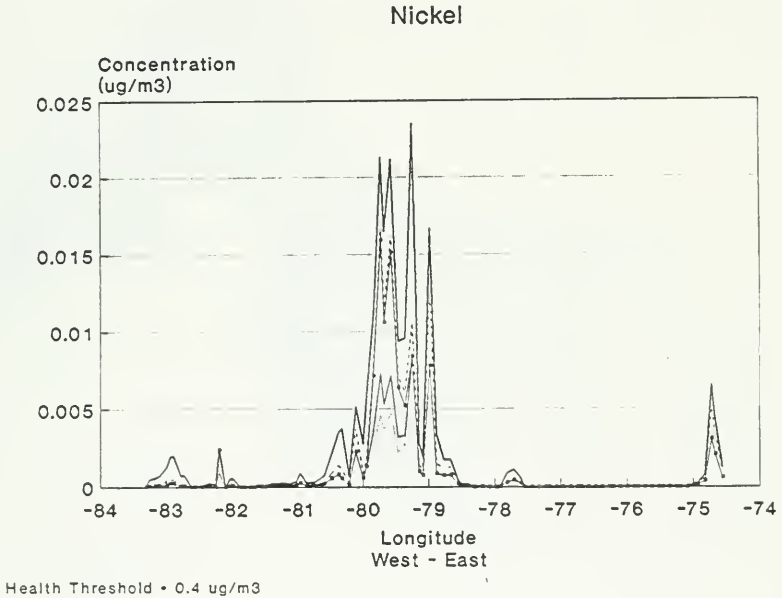


EXHIBIT I.68: PROFILE OF NICKEL CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

EXHIBIT I.69: AREAS EXPOSED TO NITROGEN OXIDES FROM REGULATION 308 SOURCE EMISSIONS

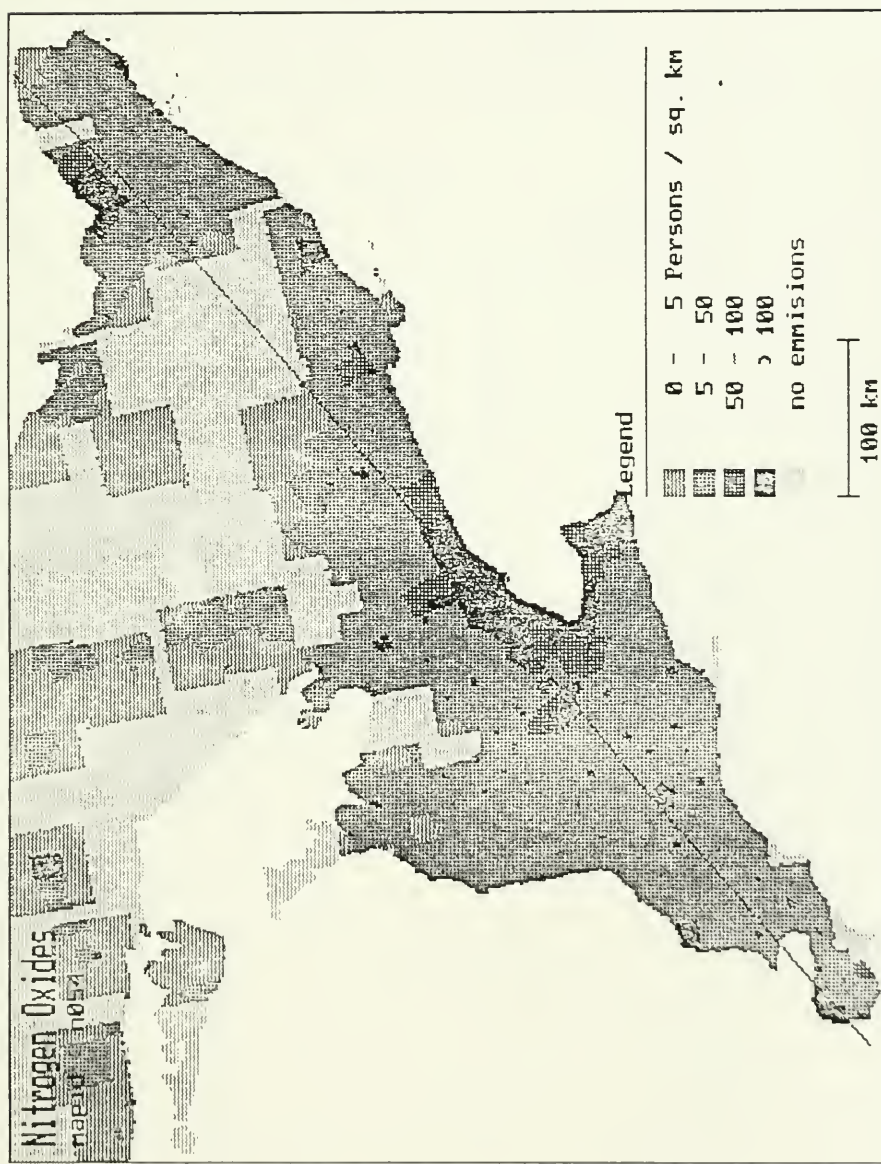
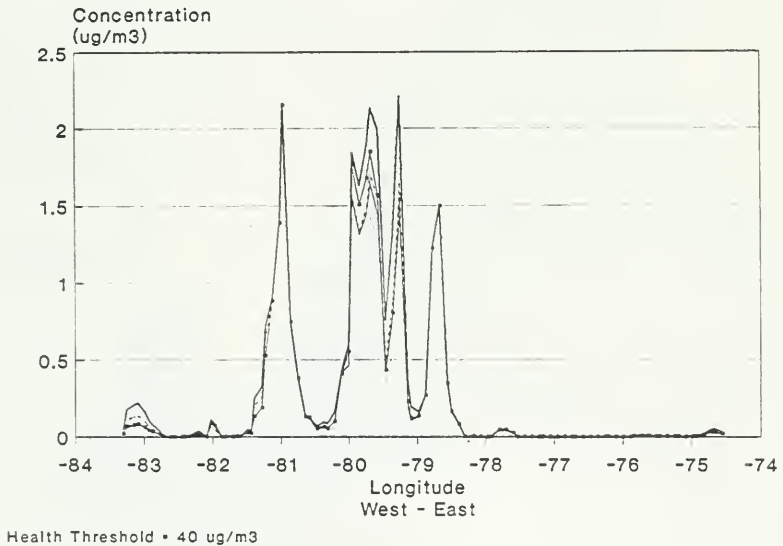


EXHIBIT I.70: PROFILE OF NITROGEN OXIDES CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Nitrogen Oxides



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

EXHIBIT I.71: AREAS EXPOSED TO PERCHLOROETHYLENE FROM REGULATION 308 SOURCE EMISSIONS

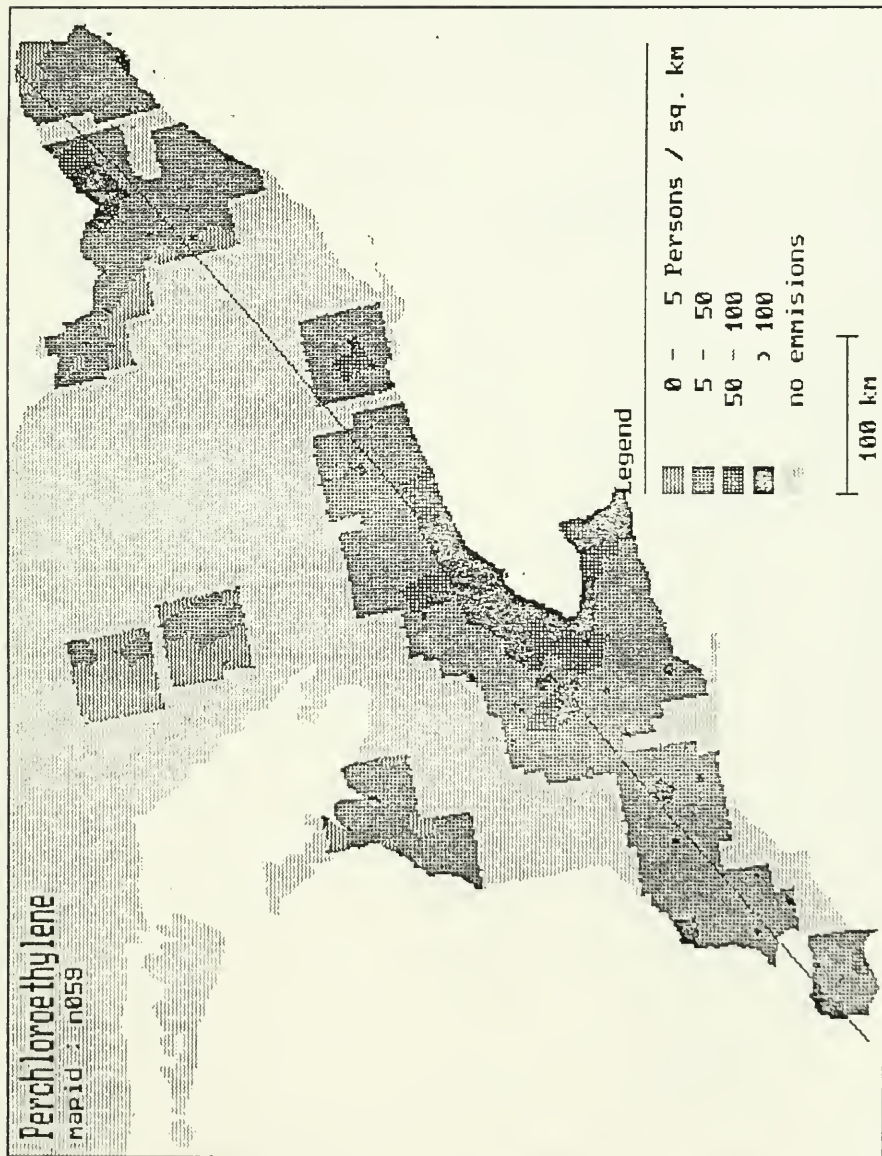
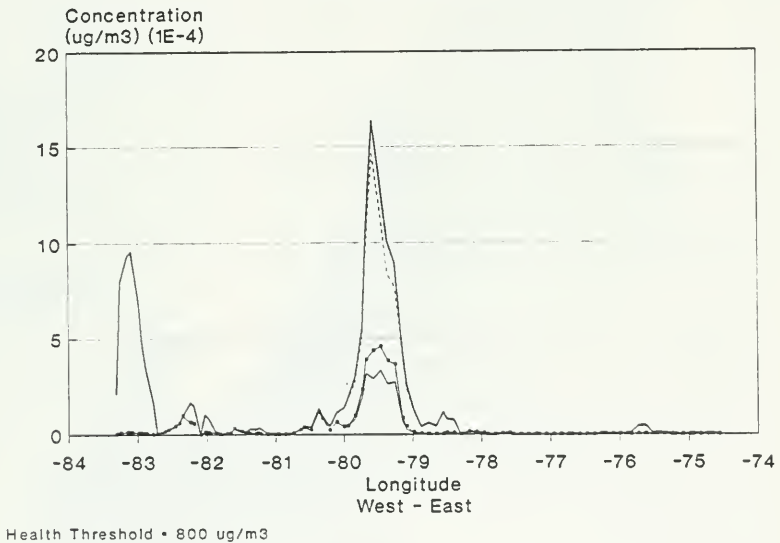


EXHIBIT I.72: PROFILE OF PERCHLOROETHYLENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Perchloroethylene



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	- - - - -
Scenario C
Scenario E	+ + + + +

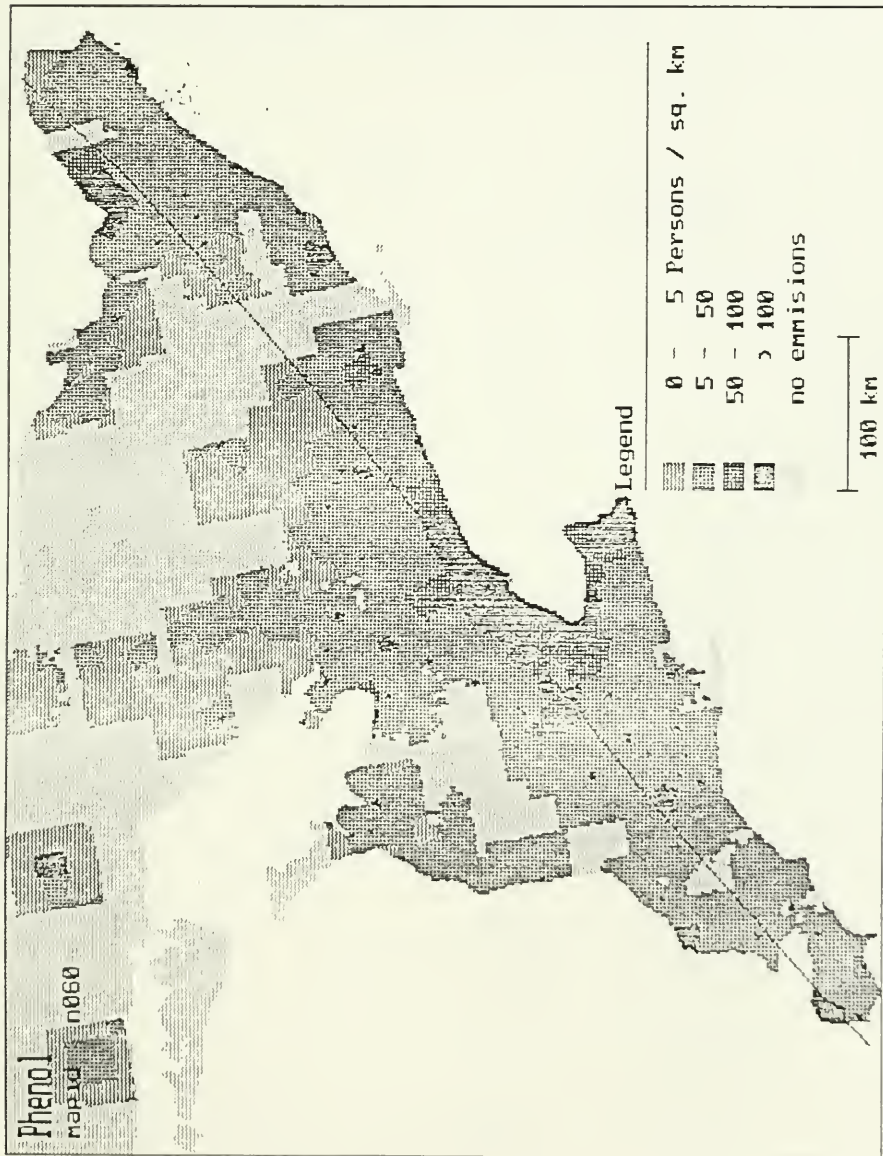
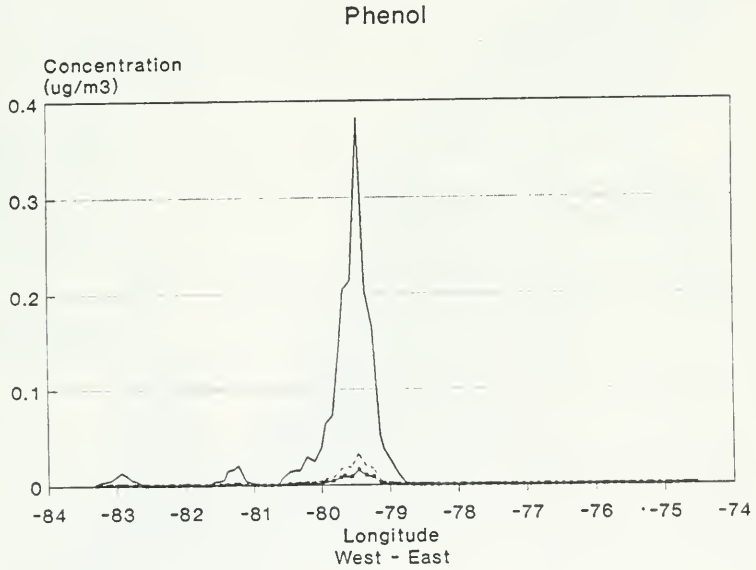


EXHIBIT I.74: PROFILE OF PHENOL CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Health Threshold = 20 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +

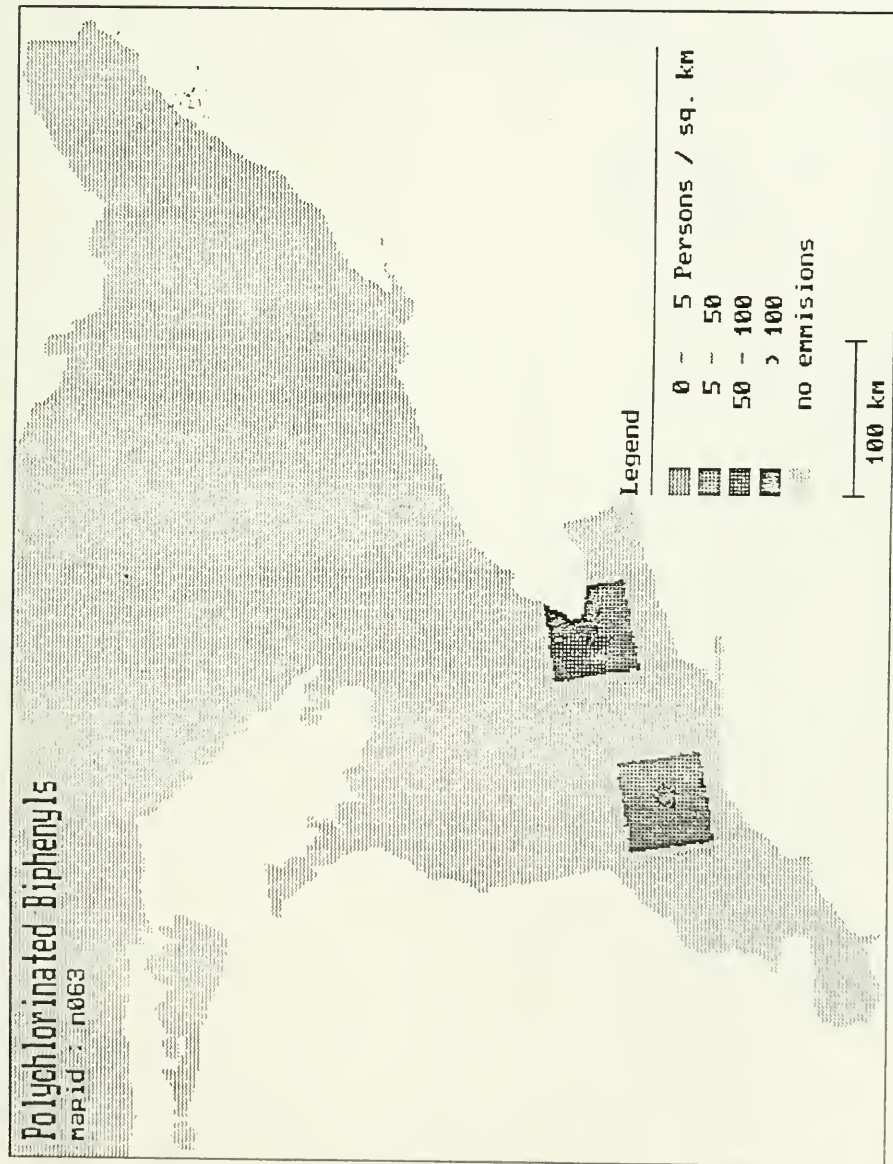
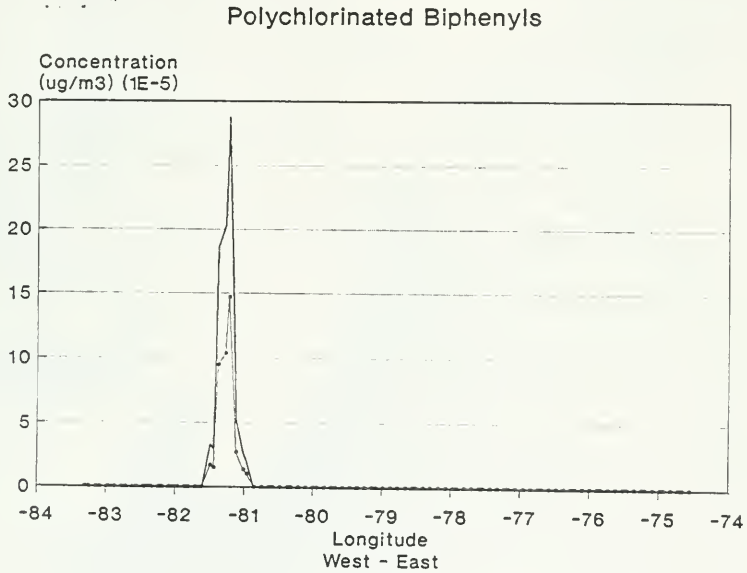


EXHIBIT I.76: PROFILE OF POLYCHLORINATED BIPHENYLS CONCENTRATION
DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS
SOUTHERN ONTARIO



Health Threshold = 0.03 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

EXHIBIT I.77: AREAS EXPOSED TO PROPIONALDEHYDE FROM REGULATION 308 SOURCE EMISSIONS

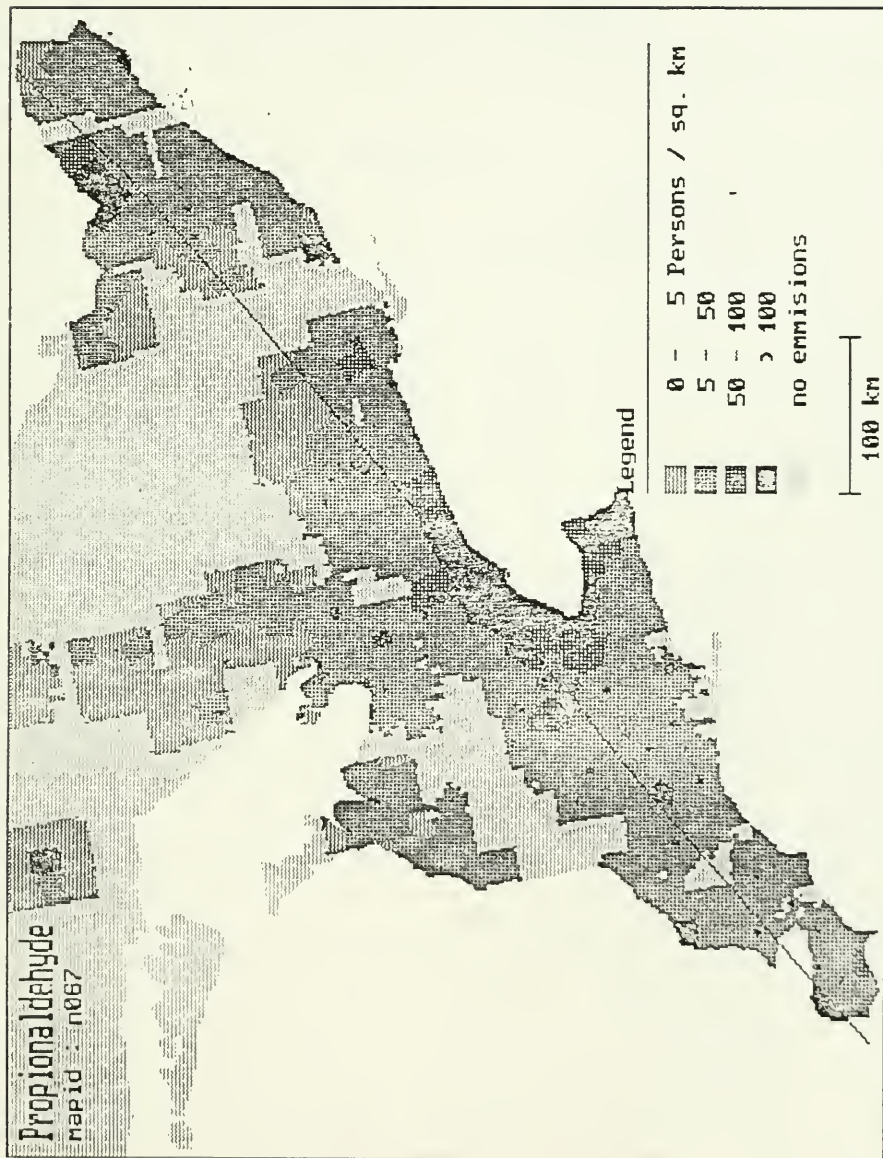
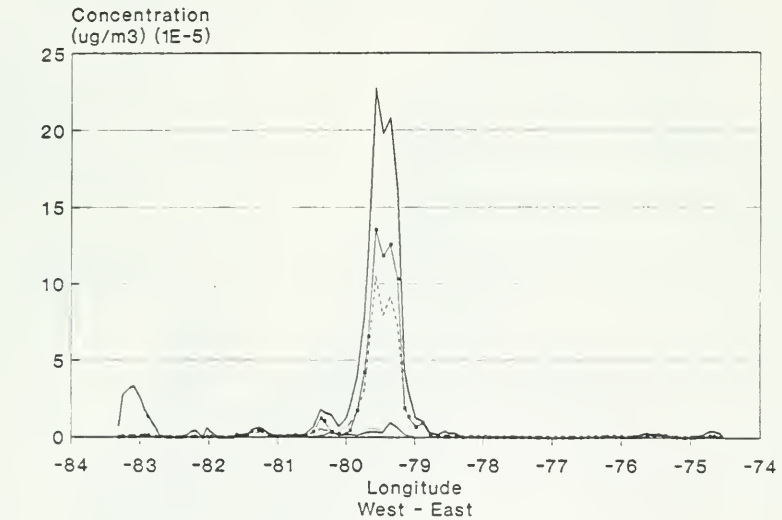


EXHIBIT I.78: PROFILE OF PROPIONALDEHYDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Propionaldehyde



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C
Scenario E	+++++

EXHIBIT I.79: AREAS EXPOSED TO PROPIONIC ACID FROM REGULATION 308 SOURCE EMISSIONS

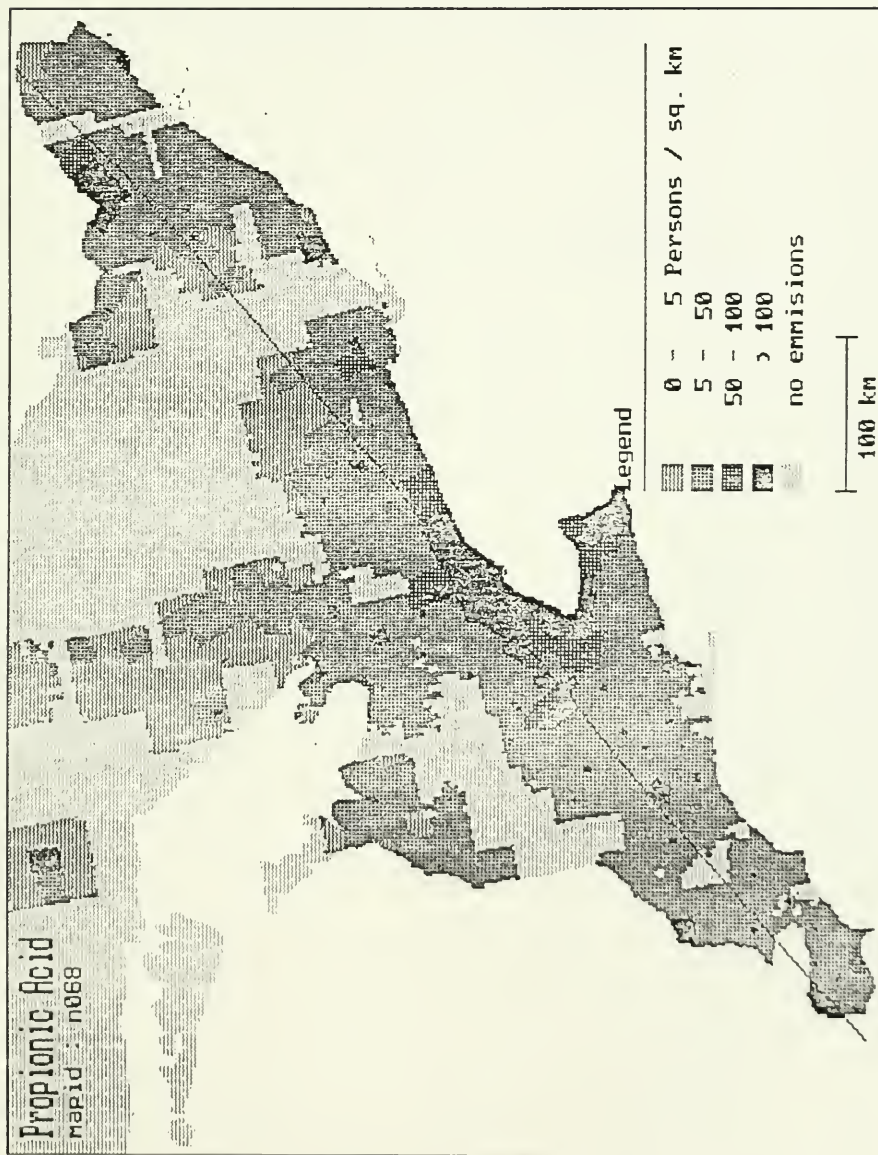
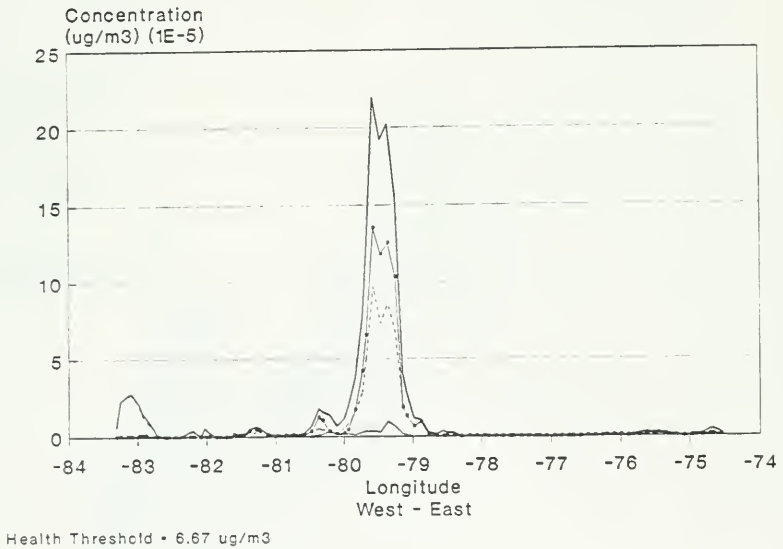


EXHIBIT I.80: PROFILE OF PROPIONIC ACID CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Propionic Acid



Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C
Scenario E

EXHIBIT I-81: AREAS EXPOSED TO PROPYLENE OXIDE FROM REGULATION 308 SOURCE EMISSIONS

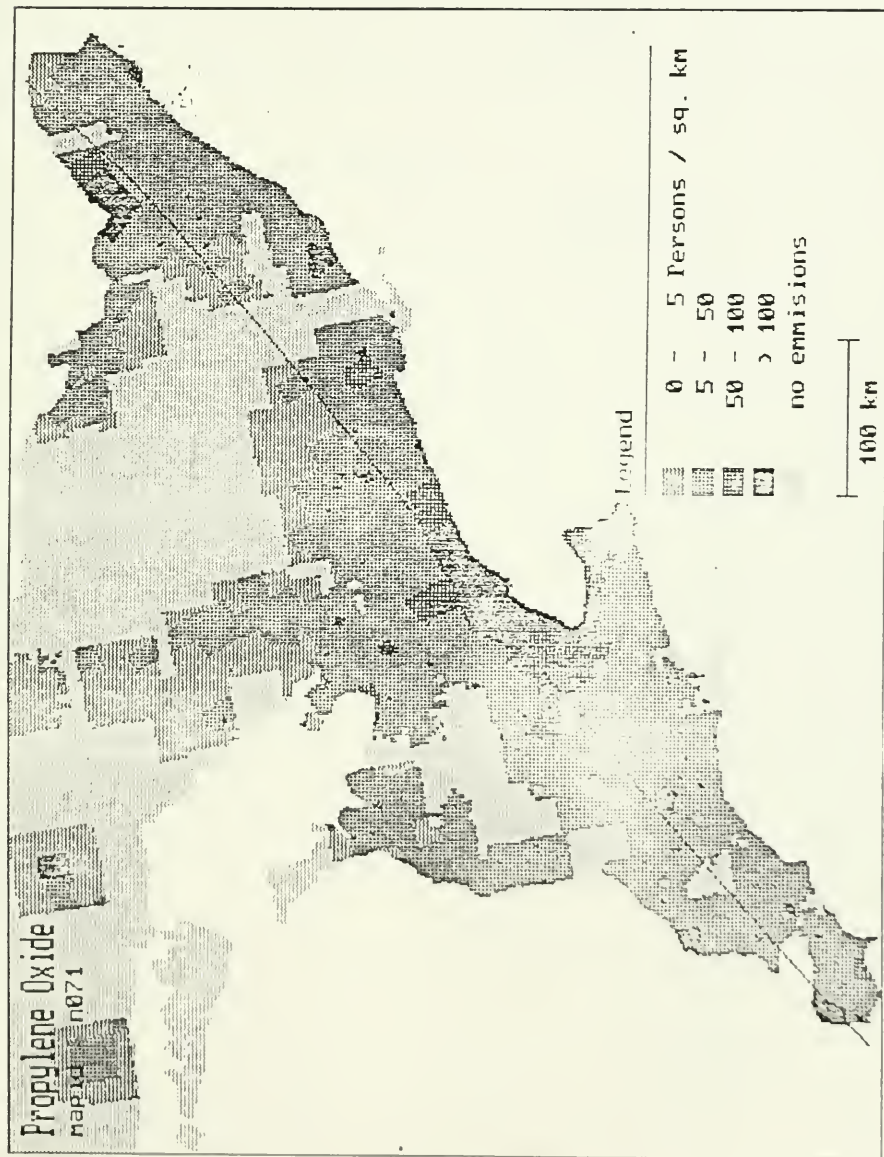
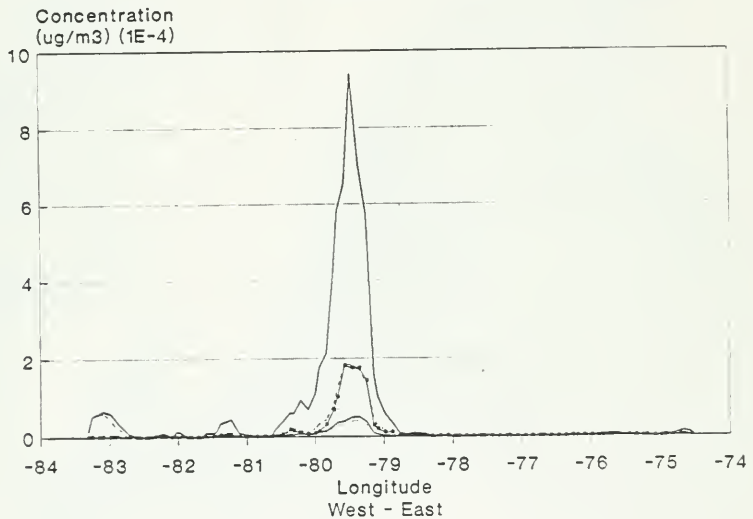


EXHIBIT I.82: PROFILE OF PROPYLENE OXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Propylene Oxide



Health Threshold = 900 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E

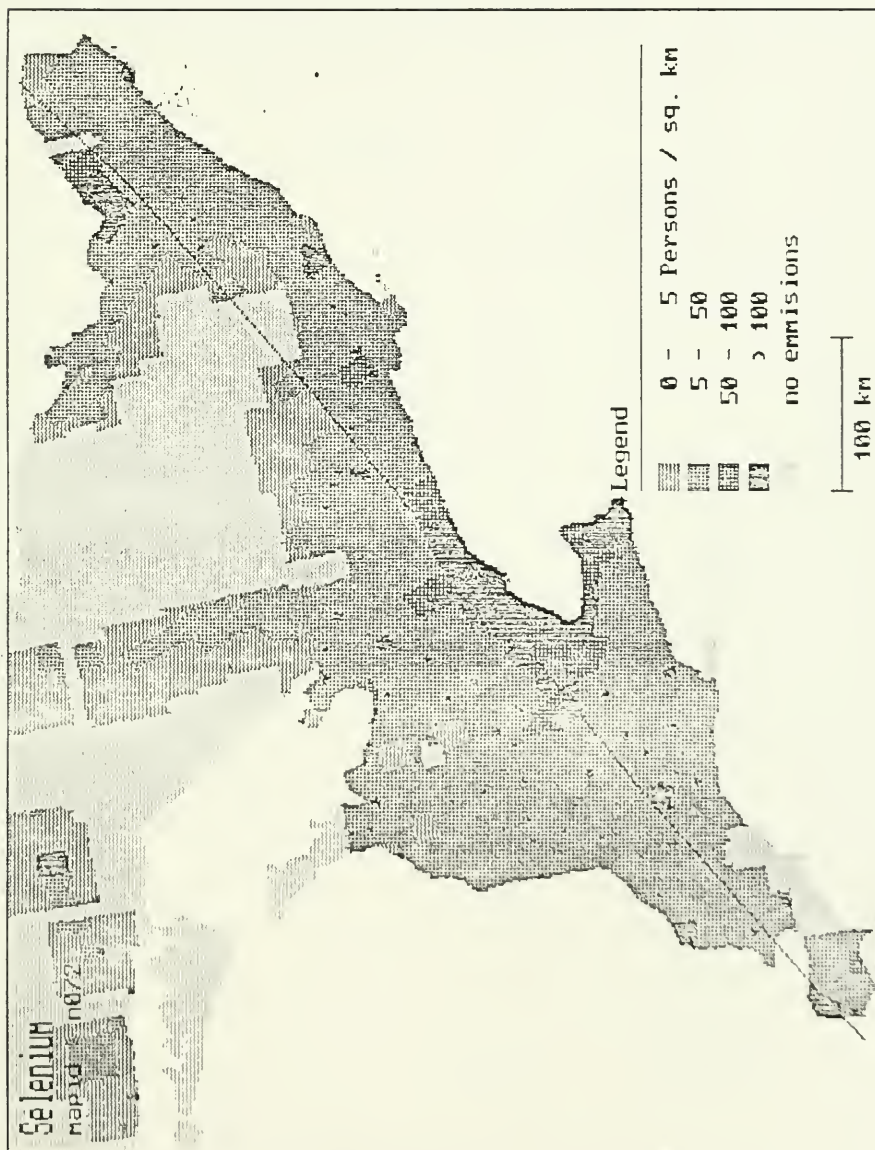
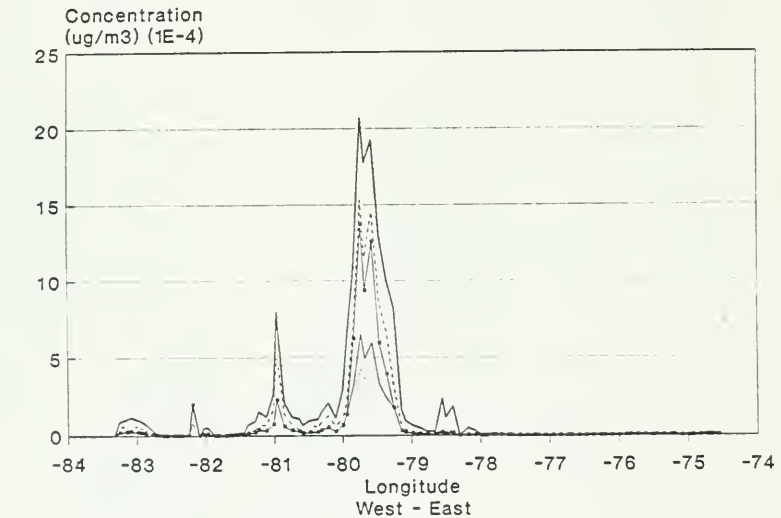


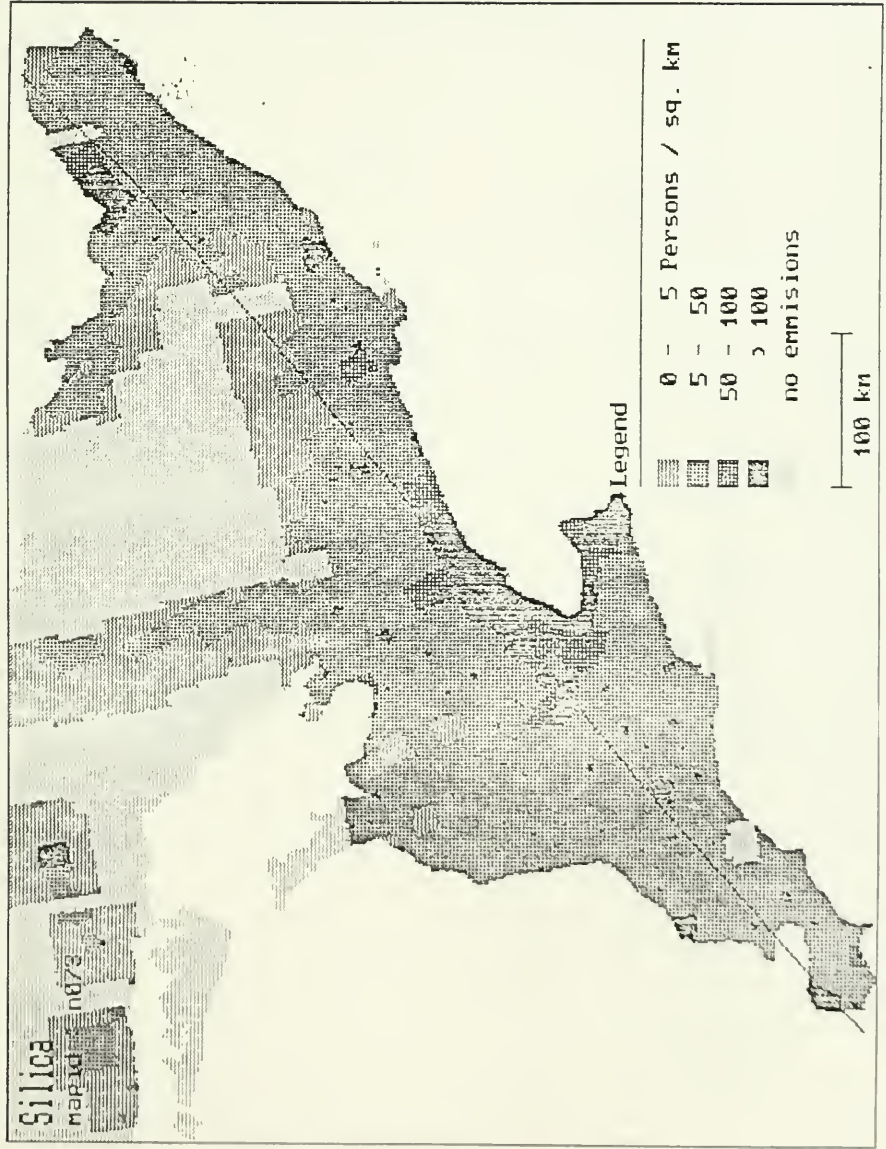
EXHIBIT I.84: PROFILE OF SELENIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Selenium

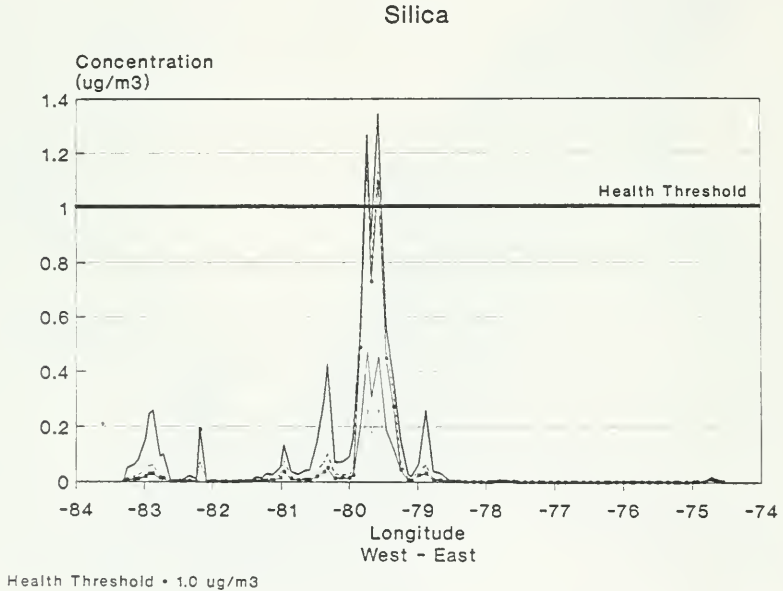


Legend

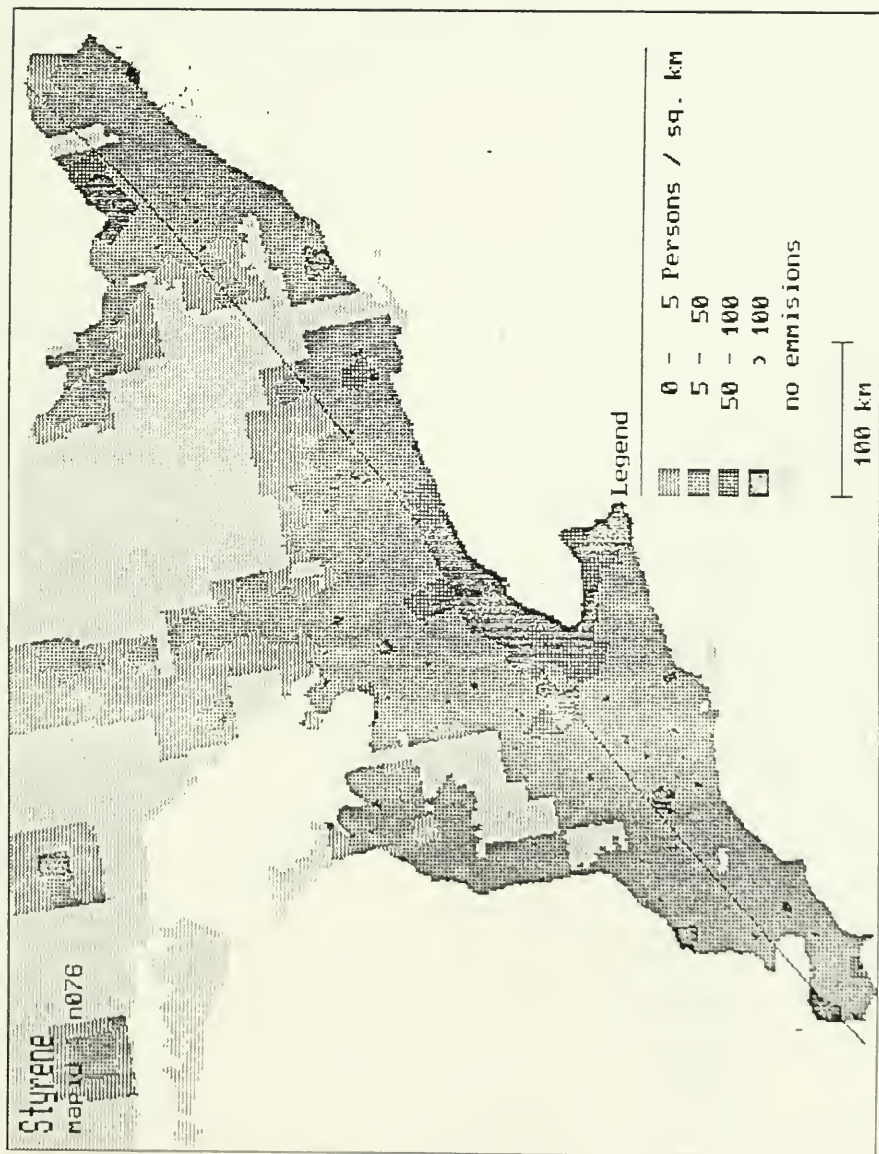
Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	+ + + + +



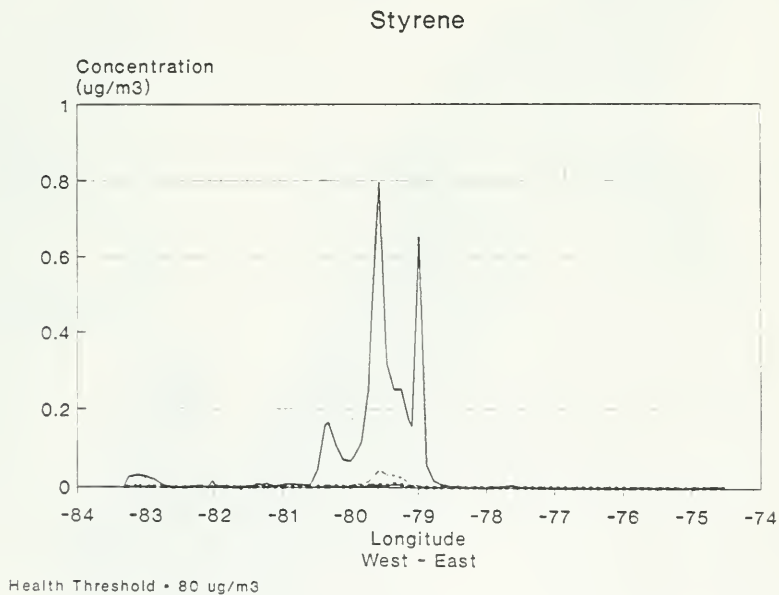
**EXHIBIT I.86: PROFILE OF SILICA CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO**

**Legend**

Existing	—————
Scenarios A & D	- - - - -
Scenario B
Scenario C	- . - . -
Scenario E	+ + + + +



**EXHIBIT I.88: PROFILE OF STYRENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO**

**Legend**

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C
Scenario E	+++++

EXHIBIT I.89: AREAS EXPOSED TO SULPHUR DIOXIDE FROM REGULATION 308 SOURCE EMISSIONS

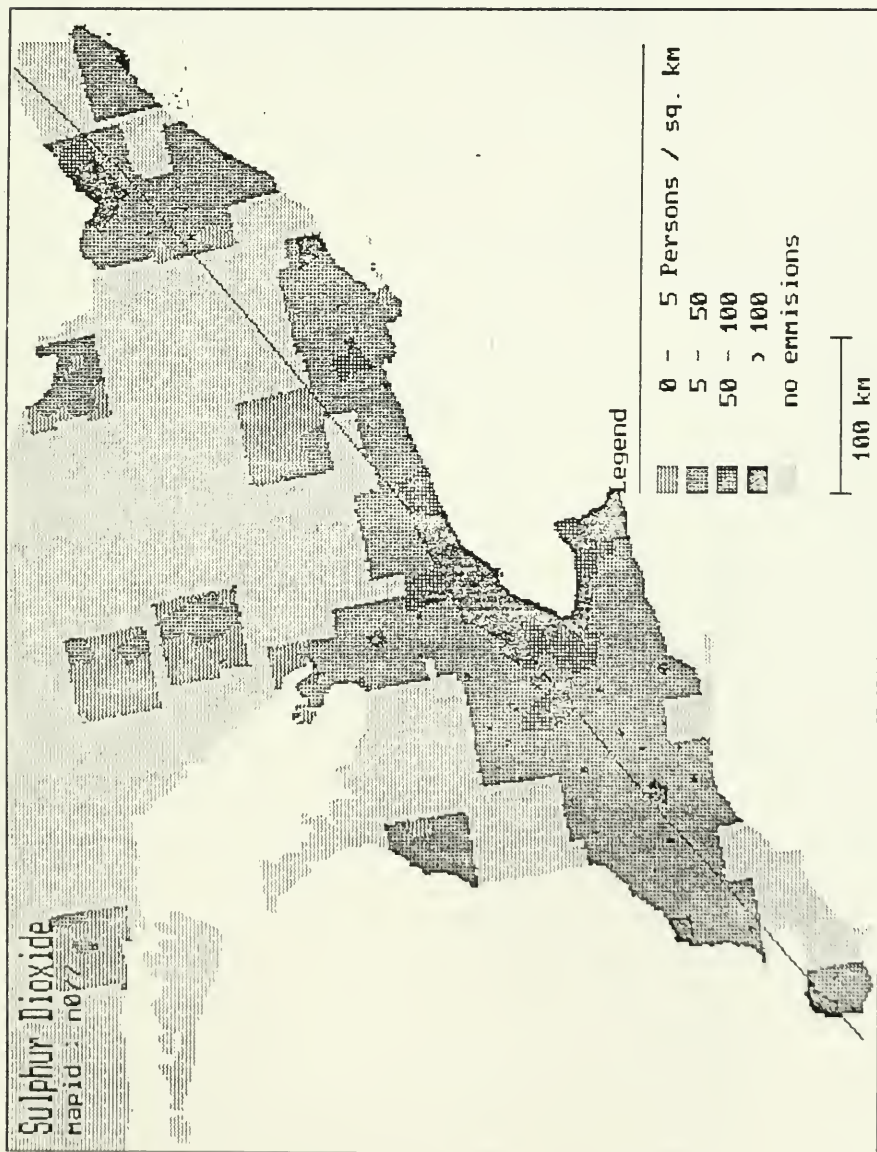
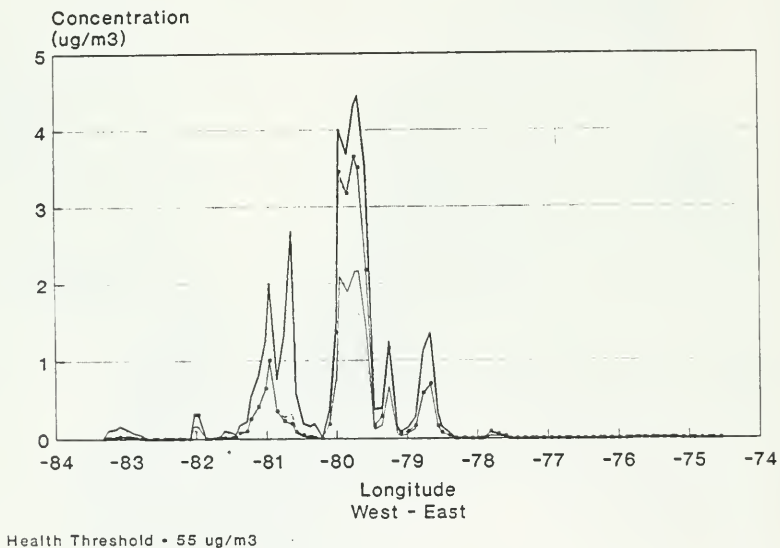


EXHIBIT I.90: PROFILE OF SULPHUR DIOXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Sulphur Dioxide



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	- - - - -
Scenario E	•••••

EXHIBIT I.91: AREAS EXPOSED TO SUSPENDED PARTICULATE MATTER FROM REGULATION 308
SOURCE EMISSIONS

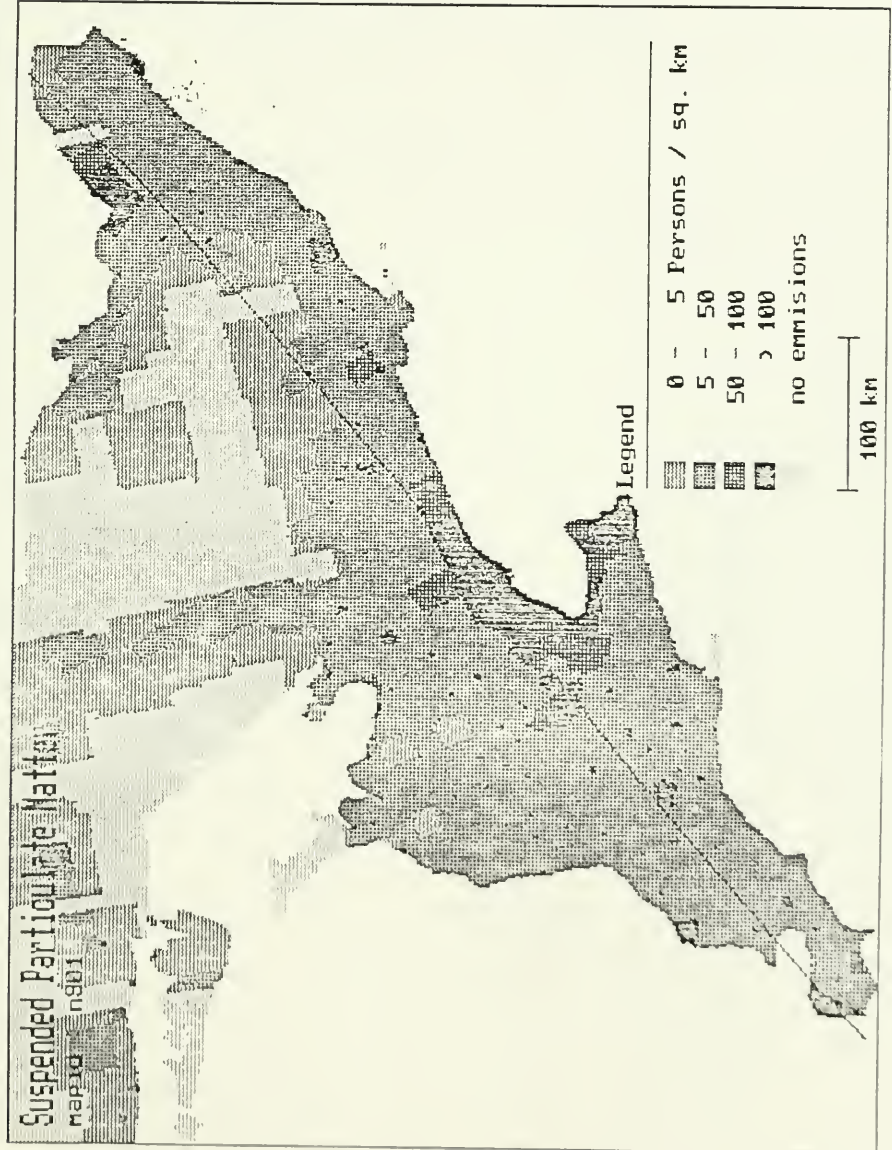
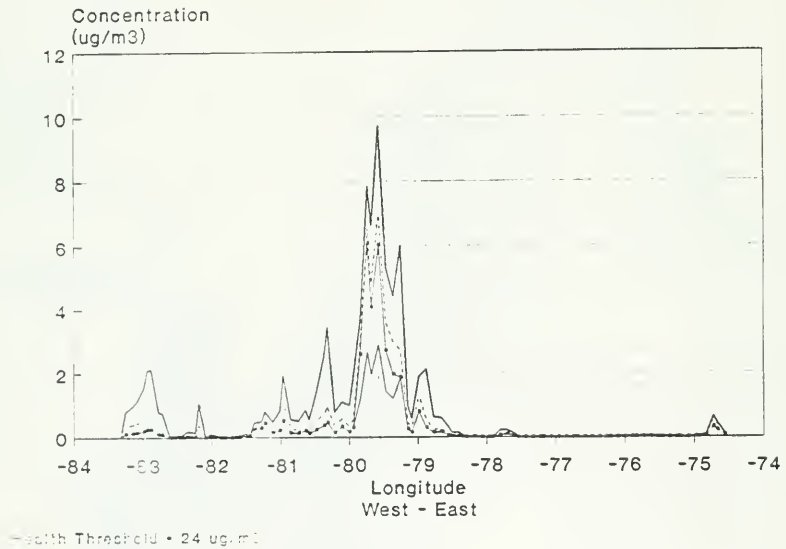


EXHIBIT I.92: PROFILE OF TOTAL PARTICULATE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Total Particulate



Legend

Existing	—————
Scenarios A & D	- - - - -
Scenario B	- . - . -
Scenario C
Scenario E	+ + + + +

EXHIBIT I.93: AREAS EXPOSED TO TIN FROM REGULATION 308 SOURCE EMISSIONS

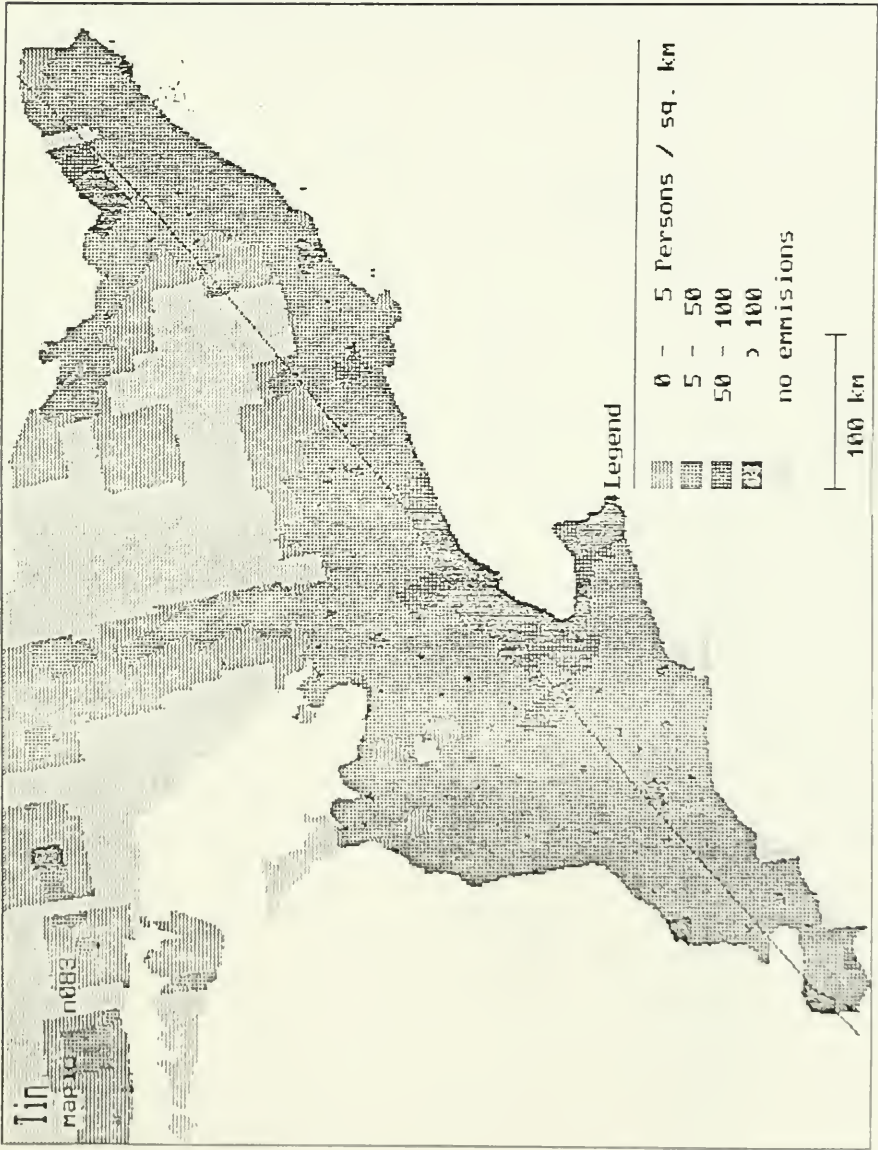
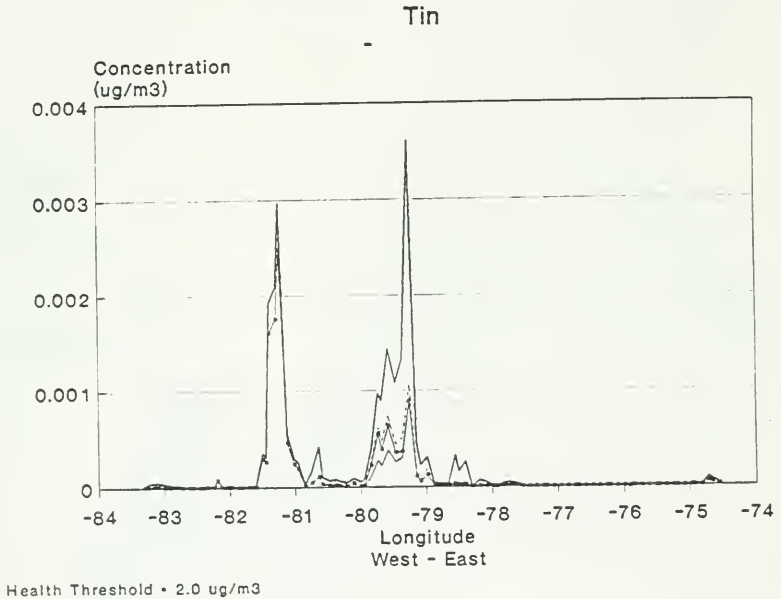
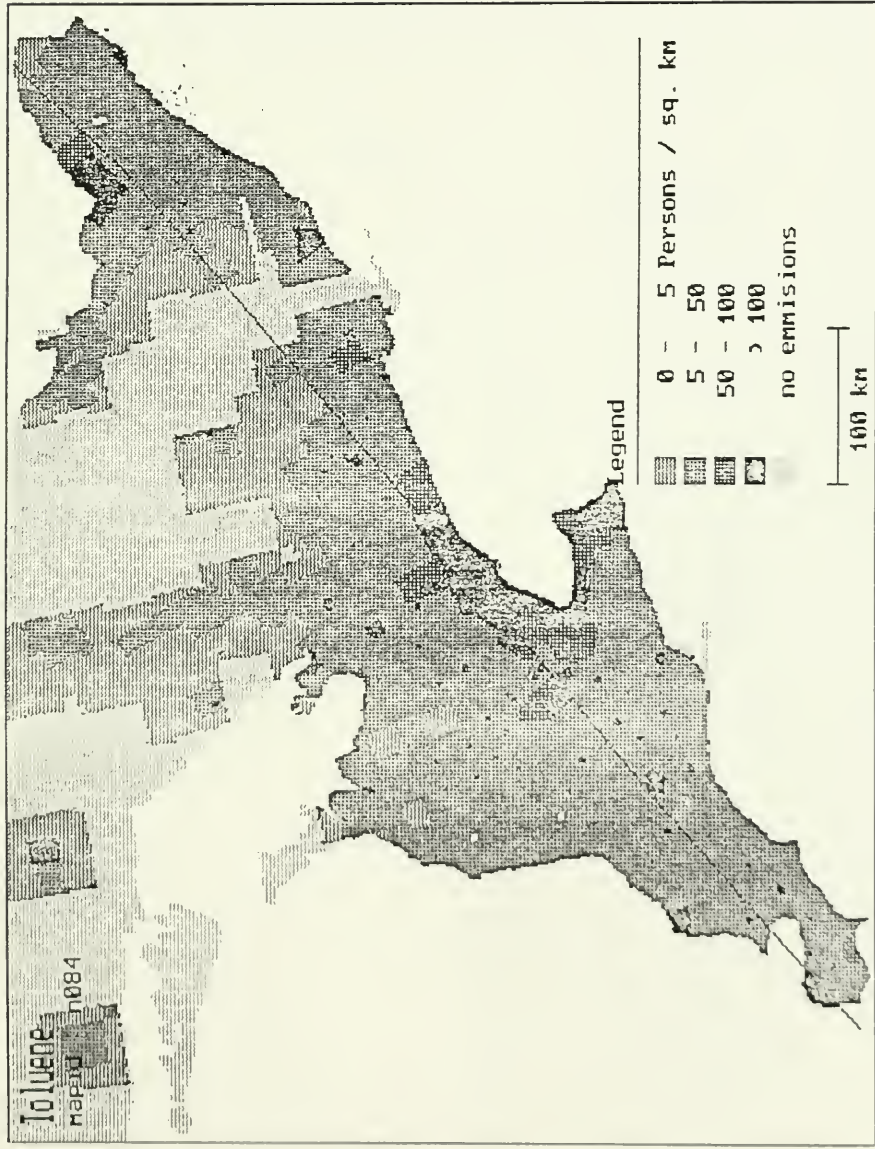


EXHIBIT I.94: PROFILE OF TIN CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

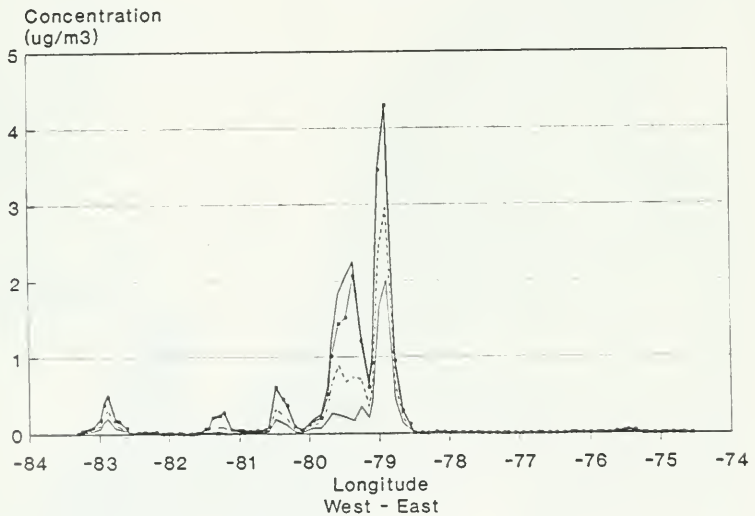


Legend

Existing	—————
Scenarios A & D	—————
Scenario B	-----
Scenario C
Scenario E	- . - . - .



**EXHIBIT I.96: PROFILE OF TOLUENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO**

TolueneHealth Threshold • 400 ug/m³**Legend**

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	+++++

EXHIBIT I-97: AREAS EXPOSED TO TOLUENE DIISOCYANATE FROM REGULATION 308 SOURCE EMISSIONS

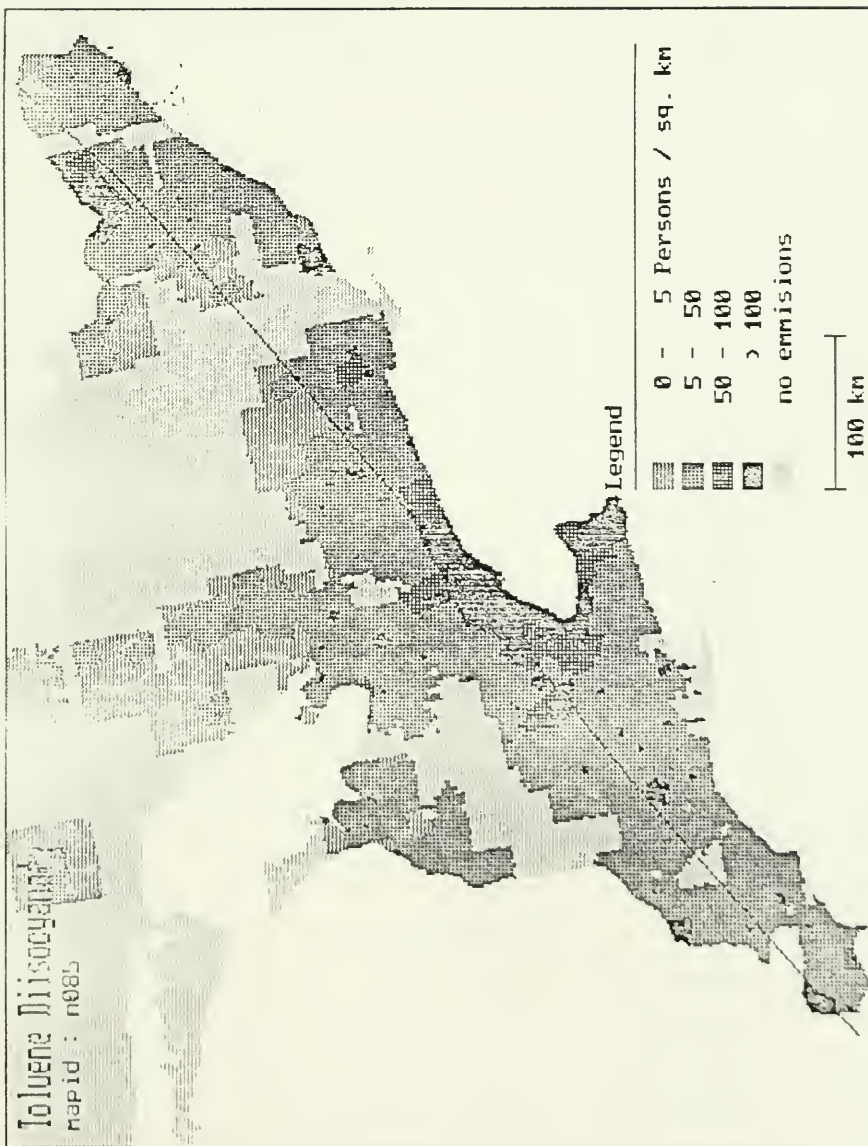
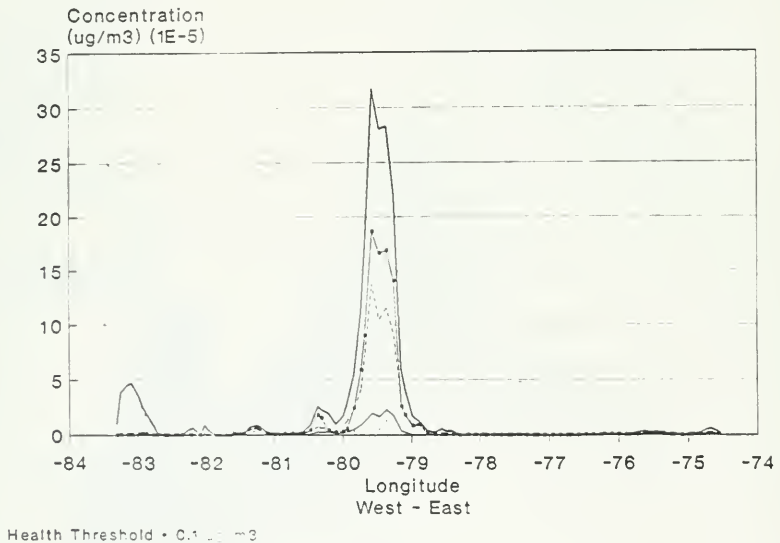


EXHIBIT I.98: PROFILE OF TOLUENE DIISOCYANATE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Toluene Diisocyanate



Legend

Existing	—————
Scenarios A & D	- - - - -
Scenario B	- . - . -
Scenario C
Scenario E

EXHIBIT I.99: AREAS EXPOSED TO 1,1,1-TRICHLOROETHANE FROM REGULATION 308 SOURCE EMISSIONS

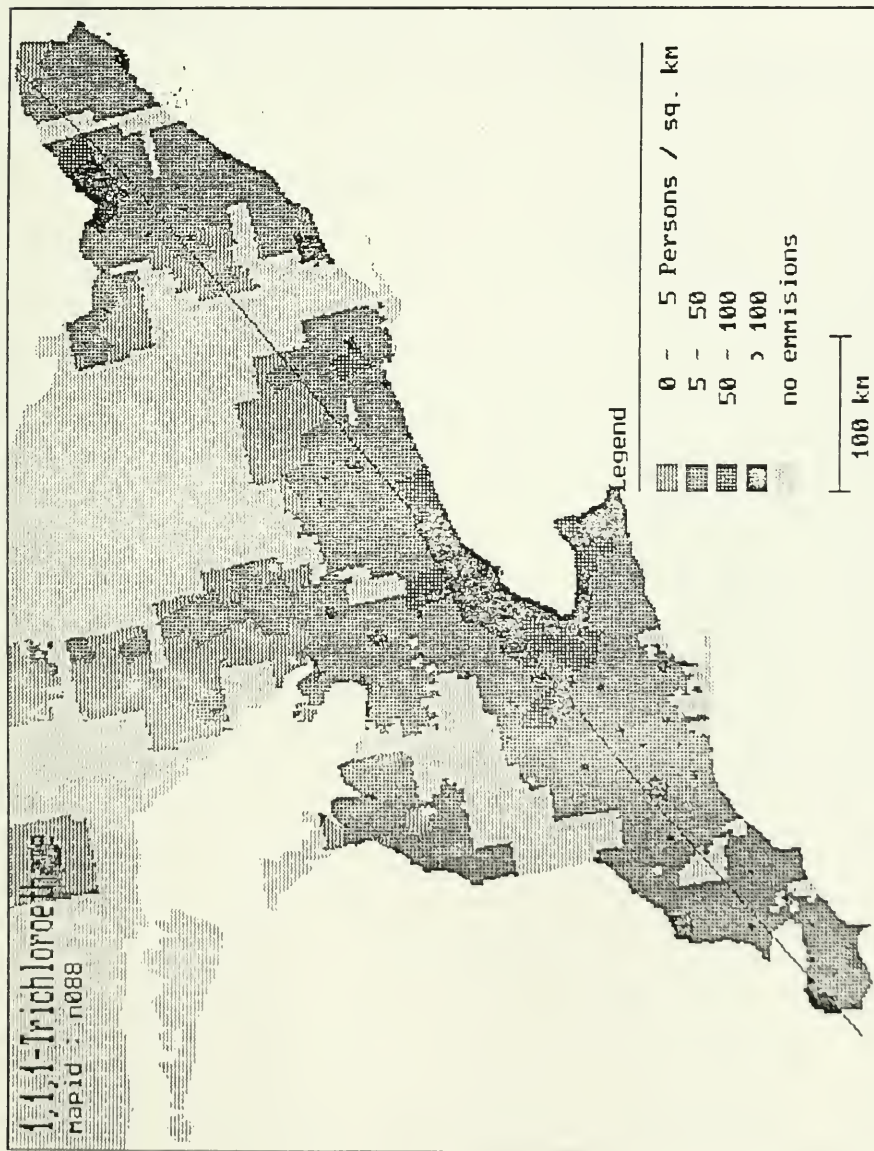
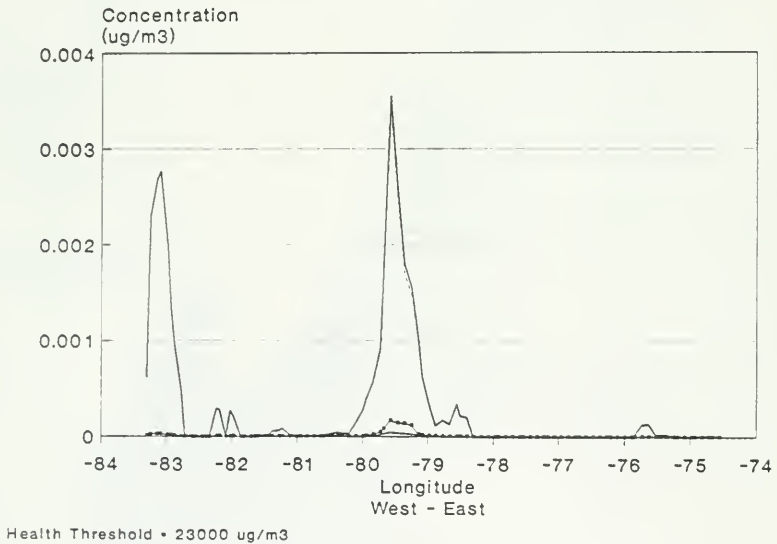


EXHIBIT I.100: PROFILE OF 1,1,1-TRICHLOROETHANE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

1,1,1-Trichloroethane



Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C
Scenario E

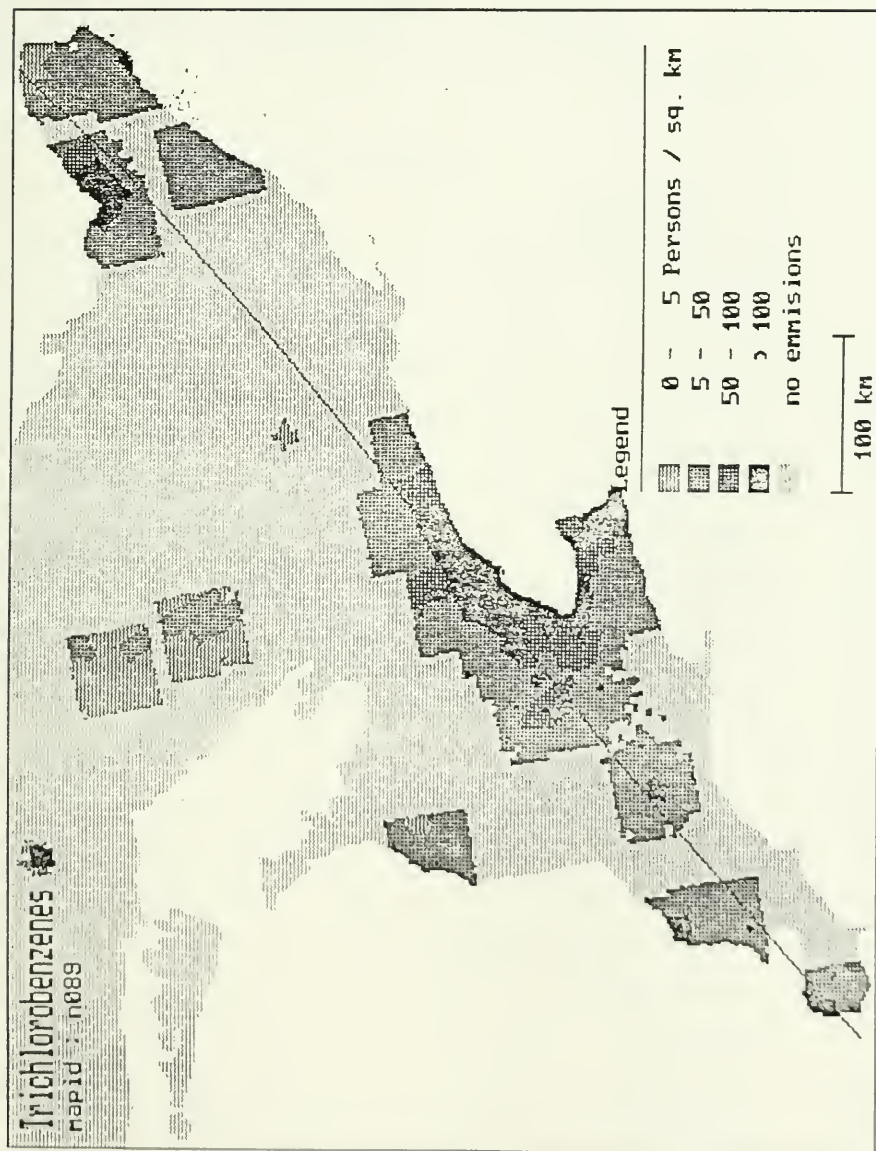
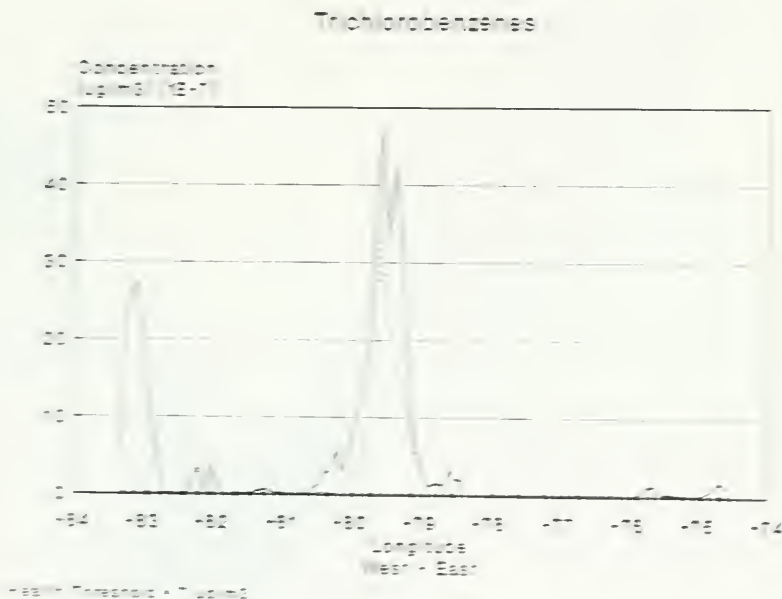


EXHIBIT 1.100: PROFILE OF TRICHLOROBENZENES CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Exposing	_____
Concentration = 1	_____
Concentration	_____
Concentration	_____
Concentration	_____

FIGURE 1-101: AUFAS EXPRESSED TO TRICHLOROETHYLENE FROM REGULATION FOR BODICE
091551045

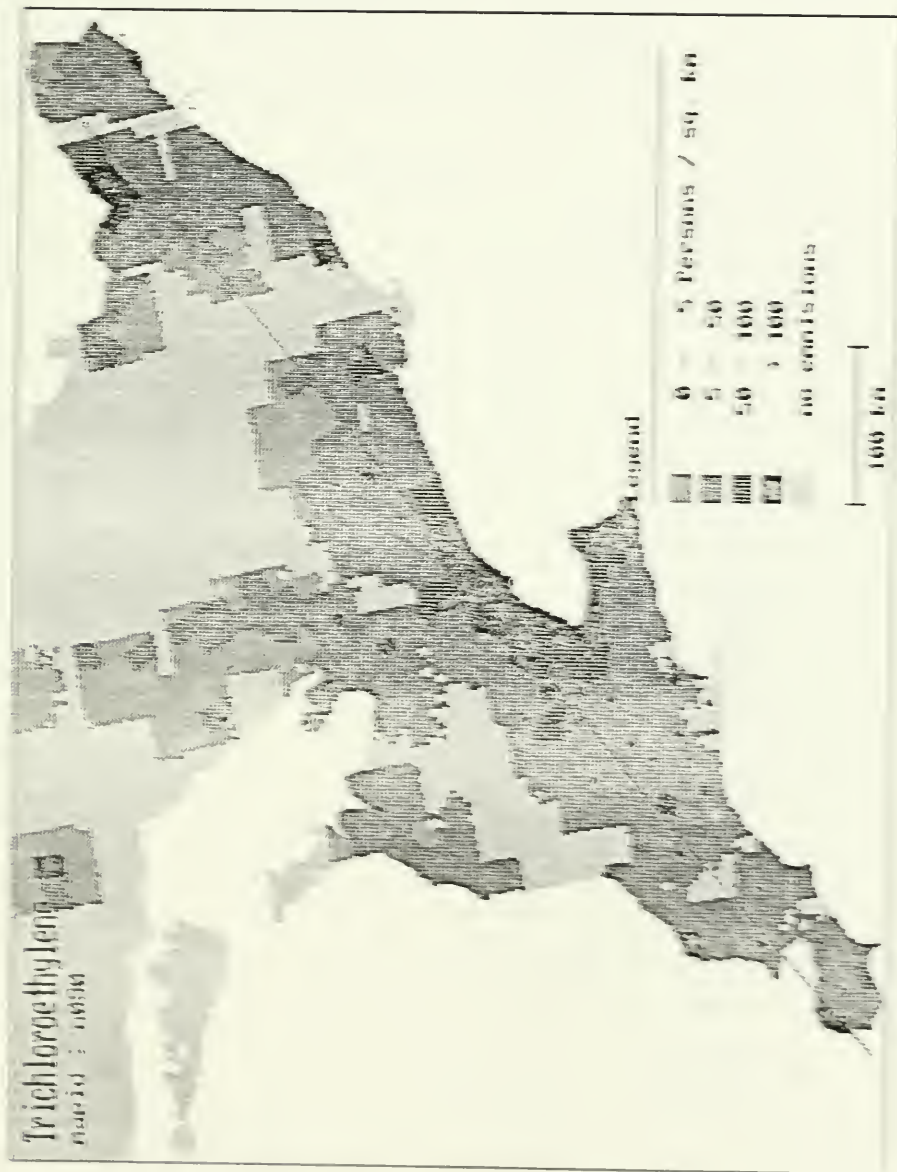
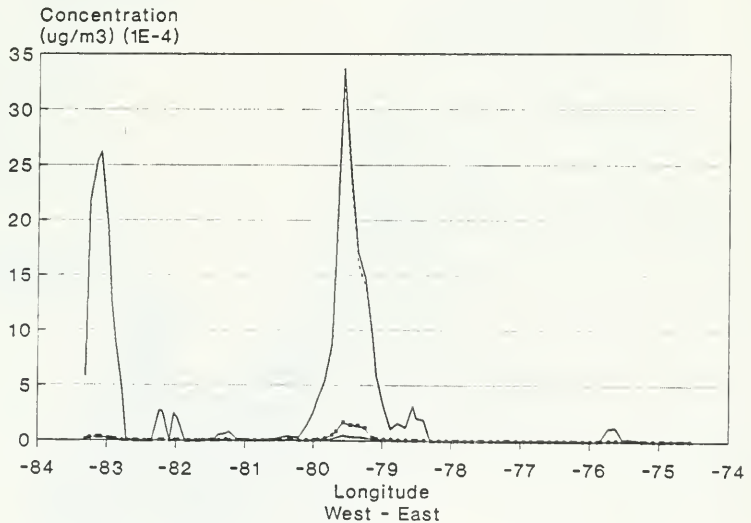


EXHIBIT I.104: PROFILE OF TRICHLOROETHYLENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Trichloroethylene



Health Threshold • 5600 ug/m3

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	—————
Scenario C	-----
Scenario E	+++++

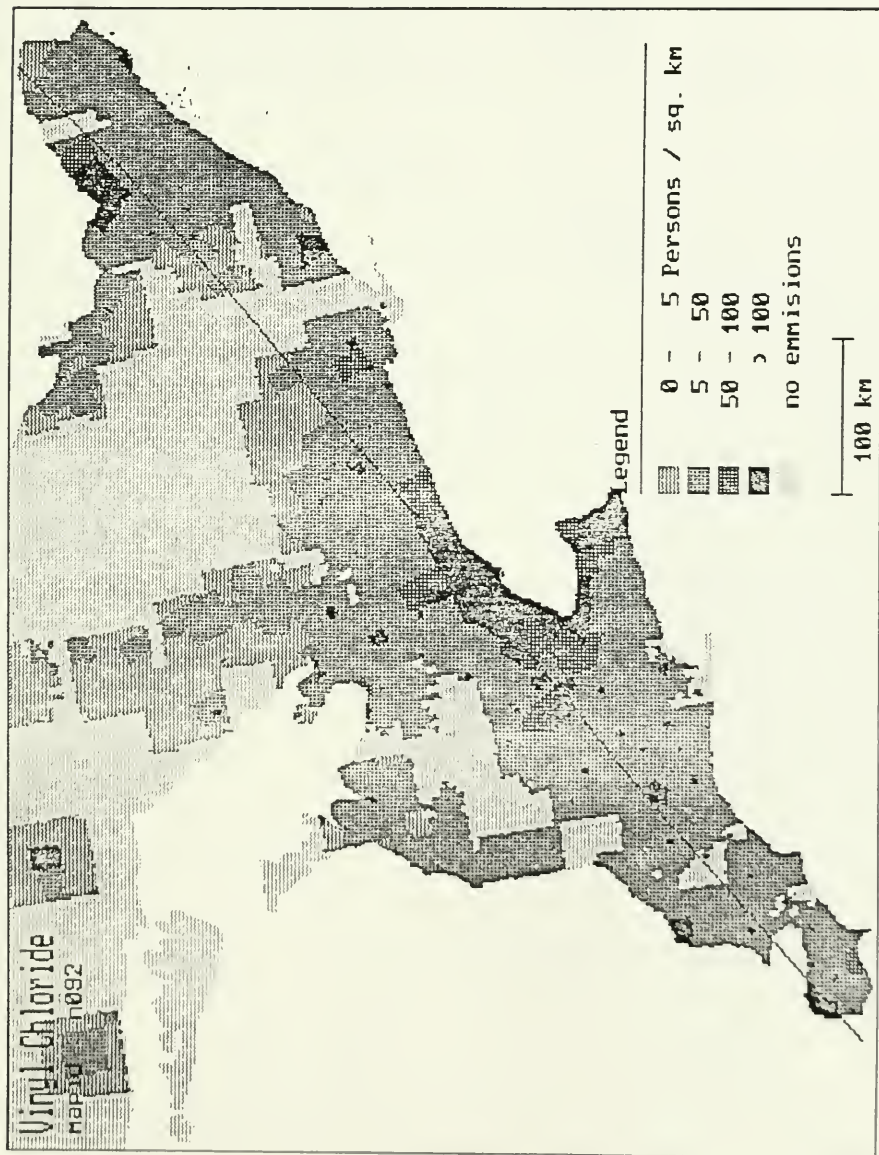
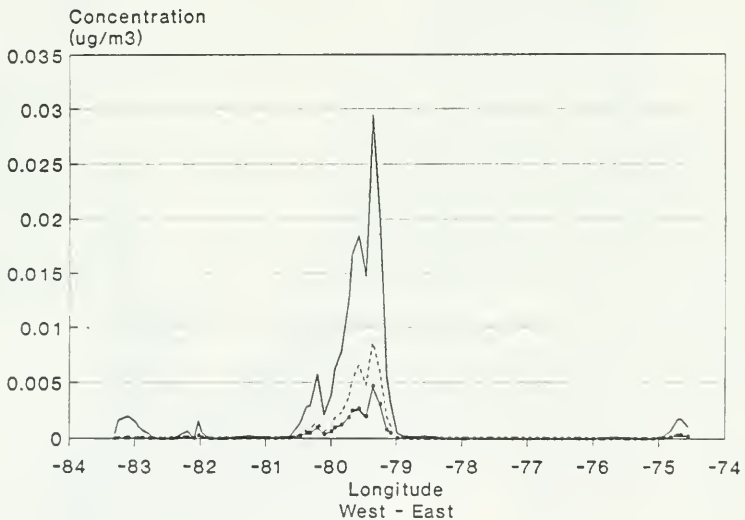


EXHIBIT I.106: PROFILE OF VINYL CHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Vinyl Chloride



Health Threshold = 56 ug/m³

Legend

Existing	
Scenarios A & D	
Scenario B	
Scenario C	
Scenario E	

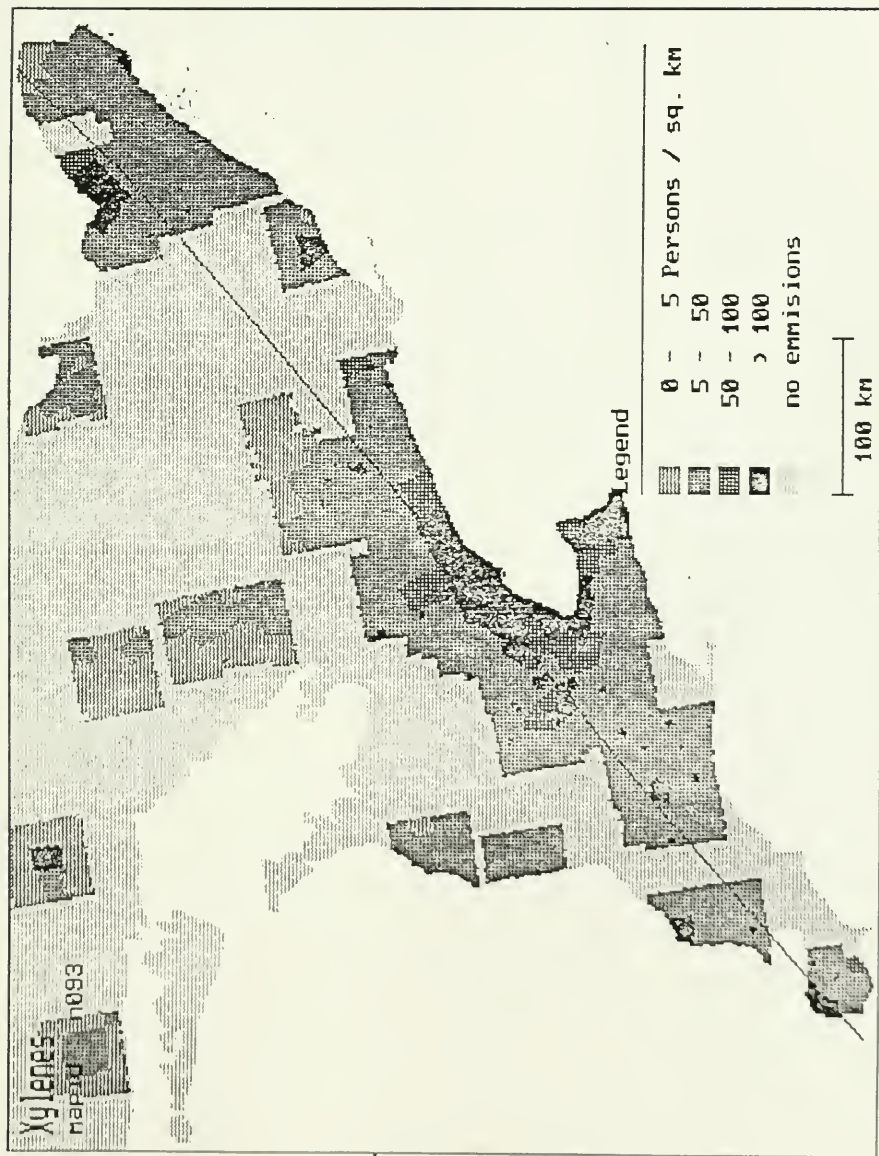
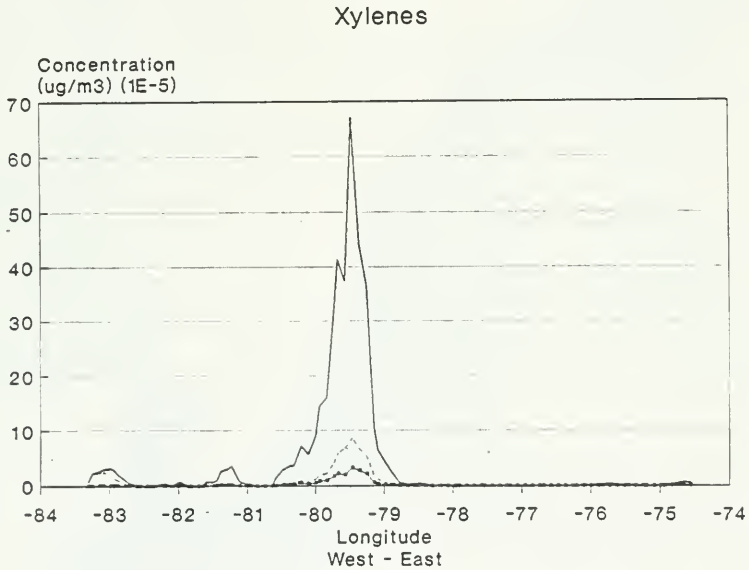


EXHIBIT I.108: PROFILE OF XYLENES CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Health Threshold = $460 \mu\text{g}/\text{m}^3$

Legend

Existing	—————
Scenarios A & D	—————
Scenario B	- - - - -
Scenario C
Scenario E	- . - . - .

